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THE SOVIET ARCTIC. SEAS AND ISLANDS

Physical-Geographical Description

by

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Foreword

The physical-geographical description of the Soviet Arctic is one of the publications of the scientific polar series "Priroda SSSR", Institute of Geography of the Academy of Science of the USSR.

The series as a whole is intended for a wide circle of readers: teachers, students, and members of the intelligentsia who are not specially engaged in the field of geography. For teachers and students the edition may serve as a handbook for lectures and lessons dealing with geography. The compilers have set themselves the task of acquainting the readers with the physical characteristics of the separate areas of our extensive Fatherland, without intending, however, to provide exhaustive reference material.

The compilers take as their basis the notion of the physiographic province (Landschaft) as an external expression of a very complicated single physical-geographical process, consisting of separate components (climatic, hydrolcgical, geomorphological, soil, and biological processes), which are interlinked and interacting. Hence, each phenomenon of nature is considered in its reciprocal relationship with the rest of the phenomena and in the process of its development.

In view of these purposes the present work falls into two parts: general characterization of the separate elements of the physical-geographic surroundings and the regional part.

In compiling the collection the following persons participated:

Corresponding member of the Academy of Science of the USSR Professor V. Yu. Vize: "Boundaries of the Soviet Article", "Study of the Arctic", "The Polar Basin", "Seas of the Eurasian Continental Shelf", "Climate";

G. V. Gorbatsky and V. N. Saks: "Physical-Geographical Description of the Areas";

V. N. Saks and G. V. Gorbatsky: "Geological Structure";

B. N. Gorodkov: "Vegetation";

G. P. Gorbunov: "The Animal Life of the Seas and Islands";

The series appear under the editorship of the academician A. A. Grigoryev and Doctor Professor G. D. Rikhter; the separate sections were edited by specialists: Doctor Professor E. M. Lavrenko (Vegetation), DoctorProfessor A. N. Formozovy (Animal Life) and others.

The cartographic editing work of all the series was done by A. H. Ulyanovy

The editors request that testimonials, remarks, and requests for further issues of the series be sent to the following address: Moscow, Staromonetny Per., 29 Geographical Institute of the Academy of Science of the USSR.

The Editors

GENERAL PART

BOUNDARIES OF THE SOVIET ARCTIC

For the definition of the concept "Arctic" it is necessary, first of all, to turn to astronomy. The word "Arctic" itself comes from the Greek name of the constellation Great Bear--"Arktos".

We know that the inclination of the sun reaches it maximum value ($23^\circ 27'$) on the days of the summer and autumn solstices, that is, on 21 June and 22 December. As a result of this, in the Northern Hemisphere, on parallel $66^\circ 33'$ ($90^\circ - 23^\circ 27'$), the sun does not drop behind the horizon during the whole day of 21 June, and on 22 December it does not rise above the horizon during the whole day. In latitudes lower than $66^\circ 33'$, the change from day to night takes place

during all the days of the year. Hence, the parallel 66° 33′ separates the areas where we have the phenomena known as the "polar day" and the "polar night" from the areas where these phenomena do not occur. In the center of the first areas are the geographical poles of the earth; hence, they are called the polar areas, and the parallel 66° 33′ is called the "polar circle". The polar area of the Northern Hemisphere is called the Arctic Zone, and the polar area of the Southern Hemisphere is called the Antarctic Zone.

The farther we go from the polar circle in the direction of the pole, the longer the polar day in summer and the polar night in winter. For example, in Malye Karmakuly, on the south island of Novaya Zemlya (latitude 72° 23′ N) the "polar day" lasts 88 days (In the computation of the duration of the "polar day" and the "polar night" we approximate the refraction due to which the sun becomes visible even when it is approximately one-half of a degree below the horizon.) and the polar night--76 days. For Tikhaya Bay on Franz Josef Land (latitude 80° 20′) the duration of the "polar day" is 138 days, and the duration of the "polar night" 126 days. At both poles the sun does not show itself above the horizon for about one-half of the year and for approximately the same length of time it furnishes illumination throughout the entire day of 24 hours. The fact that the duration of the "polar day" and the "polar night" are not exactly the same at the poles is due to the so-called precession, by which we understand the rotation of the line of the equinox (that is, the line of intersection of the plane of the terrestrial equator with the plane of the ecliptic), taking place in the direction contrary to the apparent yearly rotation of the sun. As a result of the precession, the "polar day" (or summer, that is, the time from the spring equinox to the fall equinox) lasts at the present time, at the north pole, 186 days and 10 hours, and the "polar night" (or winter, that is the time from the fall equinox to the spring equinox) lasts 178 days and 14 hours.

Hence, in the Northern Hemisphere the summer half-year period is longer than the winter half-year period by 7 days and 20 hours, and the "polar day" at the north pole is longer than the polar night by the same amount. In the Southern

Hemisphere the relationship is just the reverse: There the half-year summer period embraces 178 days and 14 hours, and the half-year winter period, 186 days and 10 hours. This relationship does not remain invariable, and after 12,900 years (precession amounts to only 50.2 for the year and consequently a full rotation requires 25,800 years.) there will be observed just the reverse picture: at the north pole the "polar day" will be 7 days and 20 hours shorter than at the south pole.

It would seem that since at the north pole the "polar day" is longer than it is at the south pole the amount of heat received from the sun would be greater at the north pole than at the south pole. In reality this is not the case: the Northern and Southern Hemispheres receive exactly the same quantity of heat. This is explained by the fact that in the summer half-year the Northern Hemisphere is at a greater distance from the sun than in the winter half-year. Conversely, the Southern Hemisphere is closer to the sun in the summer half-year.

During all the period when the sun does not show itself above the horizon at the North Pole a period which is usually called the "polar night" cannot strictly speaking be called night. Even though the sun does not rise at the North Pole for 179 days in succession, still the real night lasts for a much fewer number of days; at the beginning and at the end of the period of darkness there prevails at the poles a state of twilight, not of night. We distinguish "civil" twilight (when the sun is below the horizon by not more than 7 degrees) and "astronomical" twilight (when the sun is under the horizon by more than 7 degrees and less than 16 degrees) (sometimes we take 18° instead of 16°). During the time of "civil" twilight we can still read easily without artificial light.

(Map between pages 8 and 9. Legend: 1. Schematic map of polar basin. 2. Arctic boundaries. 3. Soviet Arctic. 4. Land boundaries of the USSR. 5. Scale.)

(Picture, page 9. Tikhaya Bay during the "polar night")

The phenomenon of the failure of the sun to rise or set is very characteristic for polar lands; hence, it is readily understandable that the first efforts to give a characterization of polar lands start with features pertaining to illumination. At the same time it is just as understandable why one took the polar circle, that is, parallel 66° 33′ as the "equatorial" limit of the polar zones. Such a determination of the polar areas, however, agrees poorly with the conception of the geographical-physiographic province. In reality, it is not difficult to see that if we take as the boundary of the north polar zone (Arctic Zone) the parallel 66° 33′ N, we shall have in the polar area certain areas whose physiographic characteristics are definitely not polar (for example, the Kola Peninsula with its pine and fir forests), whereas other areas which are conspicuously polar in physiographic characteristics (for example, the tundra of North Labrador) lie outside the polar zone. Such lack of agreement between natural (physiographic) zones and geographical parallels is explained chiefly by the lack of uniformity in the distribution of dry land and seas over the surface of the earth, and also by the systems of ocean currents, which in their turn depend to a considerable extent upon the distribution of dry land and seas.

In fixing the limits of the polar zones it would be better to take as our basis not the astronomical factors but the climatic factors. The study of the polar physiographic provinces shows that their special characteristics (absence of forests, the presence of snow and ice during the greater part of the year) are determined chiefly by the low temperature of summer. Starting from this, one proposed in due course that we use the temperature of the air in summer as a criterion for the determination of whether or not a given area belonged to the

polar regions. In this case we generally take as the s uthern boundary of the polar regions the July isotherm of 10 degrees. This conventional boundary of the polar zone was fairly well suited for the Northern Hemisphere (where it agrees in part with the northern limit of forest), but it was found to be ill-suited for the Southern Hemisphere).

Otto Nordenskiöld and Val pointed out that in the determination of the polar regions as climatic zones we cannot be limited by the temperature of summer alone, but that we must, to a certain extent, take into account the temperature of winter. For this reason one proposed the following criterion for the determination of the polar regions.

If the mean temperature of the warmest month is greater than 9 degrees - 0.1 K, in the case of which K is the mean temperature of the coldest month, the given point falls within the temperate zone; if the mean temperature of the warmest month is less than 9 degrees — 0.1 K, the given point falls within the polar zone.

To the criterion of Nordenskiöld and Val it will be useful to add still another—the mean yearly temperature of the air, and areas with a mean yearly temperature above 0 degrees are regarded as lying outside the limits of the Arctic. (In addition to the above temperature methods for determining the limits of the Arctic, we may also use others. In all of these areas the problem is to find climatic indexes which agree more or less with the south limits of the tundra. In reality, this is precisely the boundary, in so far as it is a question of dry land, and is the natural limit of the Arctic in the broad sense of the word. In the Arctic we usually distinguish two physical-geographic zones: the Arctic proper—the zone of eternal ice and cold desert or semi-desert with extremely scanty vegetation and the sub-Arctic zone of the treeless tundra — remarks of the editor). The limits of the Arctic determined on the basis of the aforementioned criteria are shown on the accompanying map.

The western and eastern limits of the Soviet Arctic were determined by a decree of the government of the USSR of 15 April 1926. In accordance with this

decree, the Soviet sector of the Arctic is limited on the west by the meridian 32° 04′ 35″ East Greenwich, on the east, by the meridian 168° 49′ 30″ West Greenwich. Hence, the extreme western Soviet possession in the Arctic is the island of Victoria in the Barents Sea, and the extreme eastern is the island of Bolshoi Diomede (Fatman) in the Behring Strait .

If we limit the Soviet Arctic by the above-mentioned lines, we can see at once that a large part of it is sea. The main part, however, of the dry land of the Soviet Arctic is constituted by the extreme north of the Eurasian continent (The continental part of the Soviet Arctic is described in other publications of the present series), whereas the islands constitute a much smaller percentage.

Among the islands of the Soviet Arctic are the following:

In the Barents Sea: the small island of Victoria, entirely covered with an ice sheet; the archipelago of Franz Josef Land (18,490 square kilometers); Novaya Zemlya (81,280 sq. km.), the island of Kolguev (3,728 sq. km.), the island of Vaigach (3,383 sq. km.), the island of Dolgi and other small islands in the extreme southeast of the sea.

In the Kara Sea: Bely island (1,902 sq. km.), Shokalskogo Island (600 sq. km.), Sibiryakov (895 sq. km.), Dikson Island and other small ones-- the Minina group of sea cliffs, fiords and rocky islands located not far from the shore of the continent between Cape Rybny and the Peninsula of Mikhailov), numerous islands near the shore of Kharitona Laptev, that is, the shore line between Mikhailov Peninsula and the Nordenskiöld archipelago, islands of Scott, Hansen, Tillo, Kaminsky, Ringness, Mona, Baklund, Belukha, Kruzenshtern, Hansen, Vonevi, Taimyr, Pilot, Alekseye, and others), the Archipelago of Nordenskiöld including about 60 island, Sverdrup, Arctic Institute, "Izvestii Tsik", Uedineniya, Vize, Ushakov , the group of islands of Sergei Kirov (consisting of 7 islands, the largest of which is Isachenko Island), Archipelago of Severnaya Zemlya (36,712 sq. km.).

In the Laptev Sea: Malyi Taimyr Island (357 sq. km.), Komsomol Pravda (1,600 sq. km.), Petr Island (302 sq. km.), Preobrazhenl Island, Bernichev Island (134 sq. km.), Stolbovoi Island (170 sq. km.), and a number of small islands and a large group of New Siberian Island (35,797 sq. km.)

(Map on page 12, areas of the Polar Basin never visited by man up to 1945)

In the East Siberian Sea: DeLong Island (200 sq. km.), Bear Island (300 sq. km.), Aion Island.

In the Chuckchee Sea: Wrangel Island (7,542 sq. km.) and Herald Island.

The total area of the islands of the Soviet Arctic is about 200,100 sq.km.

Many of the islands of the Kara Sea were discovered during Soviet rule (the islands of Sergei Kirov, Vize, Ushakov, Arctic Institute, and others). It is not likely that new islands will be discovered in the Soviet Arctic. This is evident from the accompanying map showing the areas of the polar basin never visited by man before 1945, the so-called "White Spot".

INVESTIGATION (STUDY) OF THE ARCTIC

The systematic study of the Soviet Arctic was started immediately after the elimination of intervention in the northern region. At first the investigation work was conducted chiefly in the Barents Sea, on Novaya Zemlya and in the southern part of the Kara Sea, and from 1924, after the first Soviet expedition to Wrangel Island, one began to study the eastern sector also. The beginning of the investigation of the central part of the Soviet Arctic was initiated by the expedition of the Academy of Science of the USSR to the island of Bolshoi Lyakhov (New Siberian Islands) in 1927. From 1929, after the voyage of the steam ice-cutter "G. Sedov" to Franz Josef Land for the building of a station on the island, one started regular scientific research voyages of ice-cutters into higher latitudes, voyages which resulted in a number of important geographic discoveries, chiefly in the north part of the Karskoe (Kara) Sea. Extensive expeditionary-research work in the Arctic started after the expedition of the "Sibiryakov" in 1932, which successfully solved the problem of continuous sailing over the North

Sea route from Arkhangelsk to the Pacific Ocean. As a result of this voyage, one created in this same year, through the initiative of Comrade Stalin, the Chief Administration of the North Sea route, to which one assigned the task of establishing in a definitive manner a North Sea route from the White Sea to the Bering Strait, to equip this route, keep it in good condition and assure the safety of navigation over it.

Since on the basis of the hydrometeorological regimen the south edge of the Soviet Arctic, along which passes the North Sea route, and the open part of the polar basin are closely connected with each other, it was also found necessary to study the central part of the Arctic. For this purpose, in the summer of of 1937, under the direction of "twice Hero of the Soviet Union, I. D. Papanin, a scientific research base was established on a great ice floe in the area of the North Pole. This drift station, the first in history, moved in nine months from the North Pole up to the 71st parallel in the Greenland Sea. The collaborators in the station did some scientific work which was extremely valuable and important for a knowledge of the Arctic.

(Picture, p.14. Vessels of the Lena Expedition on their way).

The study of the Central Artic was continued during the time of the drift of the "G. Sedov" from the Siberian Islands to the Greenland Sea (1937-1940), and the summer expedition of Cherevichny-Libin, which, in 1941, made a number of research landings on the ice in the area of the so-called "pole of relative inaccessibility (83° 50' N, 160° W).

Together with the carrying out of expeditionary work for the study of the Soviet Arctic one also organized hydro-meteorological stations and scientific bases. In czarist Russia there were only 4 polar meteorological radio stations,

Tugarsky Shar, Vaigach, Mare-Sale, Dikson), but by the beginning of 1946 the number of stations in the polar littoral of the continent and on the islands of the Soviet Arctic amounted to 60. The first meteorological polar radio station under Soviet rule was built in 1923 at the east mouth of the Matochkin Shar. The most northerly polar station in the Soviet Arctic (and in all the world) is the station on the island of Rudolph (Franz Josef Land)(at the present time conserved,)located on 81° 48' N. latitude.

In 1946 the Soviet Arctic had 6 permanent geophysical observatories: in Tikhaya Bay (Franz Josef Land), Matochkin Shar, on Dikson Island, at Cape Chelyuskin and Tiksi Bay and at Uellena (in Behring Straits). In addition to meteorological and hydrological observations, these observatories also make aerological, actinometric, geomagnetic and ionospheric observations.

THE POLAR BASIN

General Characteristics:

The central part of the Arctic is occupied by a deep sea known as the Arctic Ocean, which is generally called, also, the polar basin.

The fact that the Central Arctic is occupied by a deep sea was first ascertained by Nansen during the time of the drift of the "Fram" in 1893-1896 from the New Siberian Islands to Spitsbergen. The measurements made by Nansen discovered depths exceeding 3,000 meters. In the parts of the polar basin around the pole the depth, as shown by measurements of the Soviet drift station, "Severny Polius" in 1937, are still greater. For example, between the North Pole and parallel 85° North, in the area of the meridian of Greenwich, the depths of a large part exceed 4,000 meters. The maximum depth. measured by the drift station, was 4,395 meters. The deepest measurement, however, made up until now in the polar basin is 5,182 meters; this depression was discovered during the time of the drift of the "G. Sedov" in North latitude 86° 26' and east longitude 36° 25'.

The waters of the polar basin bathe the northern edge of the Eurasian continent, forming over this submerged part of the continent (the so-called con-

tinental shelf) a number of shallow seas. The dividing line between these seas and the deep waters of the polar basin is known as the continental slope, an area which is characterized by an abrupt increase in the depth of the sea from 200 - 2,000 meters. The location of the continental slope to the north of Eurasia is now determined with sufficient precision only in a few places of the Arctic.

On the Eurasian continental shelf we distinguish five shallow seas, contributing a part of the Soviet sector of the Arctic; the Barents Sea (between Spitzbergen and Novaya Zemlya), the Kara Sea (between Novaya Zemlya and Severnaya Zemlya), the Laptev Sea (between Severnaya Zemlya and the New Siberian Islands), the New Siberian Sea (between the New Siberian Islands and Wrangel Island), and Chuckchee Sea (between Wrangel Island and the north tip of Alaska). The southern limits of all the above-numerated seas is constituted by the shore line of the continent and we may take the continental shelf as their north limit.

The deepest of the seas of the continental shelf is the Barents Sea, the average depth of which is 200 meters. A deep trough runs into the Barents Sea from the west (a depth of more than 400 meters); this trough consists of a broad submarine valley, joining up with the deep depression of the Greenland Sea. The extreme southeast part of the Barents Sea is known as the Pechora Sea. The Barents Sea communicates with the Kara Sea by means of three straits (Yugorski Shar, Karskie Vorota, and Matochkin Shar) and by the broad passageway between Novaya Zemlya and Franz Josef Land.

The relief of the Kara Sea is very uneven; along with large shallow areas (for example, to the north of Ob Bay (Obskaya guba) and the Yenisei Gulf) it has relatively deep depressions, the largest of which are the Novozemelskaya (eastern shores of Novaya Zemlya) with a depth up to 500 meters, the Sv. Anna trough on the extreme northwest part of the sea, with a depth of over 500 meters and the Voronin trough, with a depth of over 300 meters in the northeast part of the sea. The last two troughs, separated by the Tsentralnaya submarine ridge, are connected directly with the deep water polar basin. On the Tsentralnaya submarine ridge, discovered by the expedition on the "G. Sedov" in 1930, are the islands of Uedineniya, Vize, and Ushakov. The Kara Sea is connected with the Laptev Sea by the broad Boris Vilkitsky straits (between the continent and Bolshevik island) and by two narrower Severnaya Zemlya straits (the strait of Shokalsky and Krasnaya Armiya strait).

The seas lying to the east of the Taimyr Peninsula are still shallower than the Barents and Kara Seas: their depth does not exceed 100 meters at any spot. A deep bay of the polar basin cuts into the Laptev Sea from the north, a fact which was ascertained by the expedition on the "Sadko" in 1937, which measured a depth of 2,385 meters on meridian 118° east and on latitude 78° 31' north. Between the Laptev Sea and the East Siberian Sea are the straits of the New Siberian Islands: Dmitrii Laptev, Yeterikan and Sannikova.

(Map between pages 16 and 17: 1. Surface currents, limits of ice and drift of vessels in the Arctic.

Legend: 1. Surface currents 2. Mean southern limits of ice in August. 3. Drift of vessels and of the North Pole stations. 4. Deep part of the ocean (over 3,000 meters). 5. Depth in meters.

The largest shallow sea is the East Siberian Sea, which is also distinguished by the unusually even relief of its bottom. For characterizing the depth of the sea we may point out that the "Litke", which made a continuous voyage in over the North Sea route, in 1934, had in its voyage from the mouth of the Kolyma up to Bolshoi Island of the Lyakhovskie group a maximum depth of 23 meters; over the greater part of the way, however, the depths were less than 20 meters. In the East Siberian Sea the depths reach 60 meters only at a distance of about 600 km from the shores of Siberia.

In the Chuckchee Sea the depths vary for the most part from 40 - 60 meters. To the north of the Behring Strait, about 70th parallel, there are shallow places (less than 20 meters) known as the Herald Banks. The Chuckchee Sea is connected directly with the Pacific Ocean by the Behring Strait having a width of 85 km and an average depth of about 40 meters.

In the main, the Polar Basin is filled with water brought from the Atlantic Ocean, with its physical and chemical qualities changed under the influence of the Arctic conditions. The great mass of the Atlantic water, which is characterized by its relatively high salt content (more than 3.5%) and relatively high temperature, is brought into the polar basin by the Spitsbergen Atlantic stream, which passes to the west of Spitsbergen flowing from the south towards the north. This stream is a direct continuation of the Atlantic current, in its turn carrying the water of the Gulf Stream. The junction of the Spitsbergen Atlantic current with the Gulf Stream and the Florida current is proved, among other things, by the finding on the shores of Spitsbergen of beans Entada gigalobium growing in the West Indies.

The waters of the Spitsbergen Atlantic current, after bending around

Spitsbergen from the north, flow towards the northeast and sink to a certain depth, being covered by the cold and relatively fresh (and, hence, light) "polar water". The Atlantic water in the polar basin was discovered by Hansen during the time of the drift of the "Fram". The observations of Nansen showed that in the parts of the polar basin visited by the "Fram" all the layer of water at a depth from 200 to 800 - 900 meters has a "positive" temperature, whereas above and below this layer the water has a temperature below 0°. This relatively warm water is the water brought by the Spitsbergen Atlantic current. In the area of the drift of the "Fram" the temperature of this water reaches its maximum at a depth of about 300 meters, the temperature here being plus 1 degree or somewhat more.

In accordance with observations made by the Soviet drift station, the layer of the relatively warm Atlantic water is in the area of the North Pole, where the upper limit of this layer is at a depth of 215 meters, and the lower limit at a depth of 680 meters, and the maximum temperatures (plus 0°. 79) was observed at a depth of 400 meters. These same Atlantic waters were discovered in the area of the "pole of relative ~~relative~~ inaccessibility" by the expedition of Cherevichny-Libin.

Apparently, there is a layer of Atlantic water in all the deep part of the polar basin. At the same time the Atlantic elements (that is, the relatively high temperature and saltiness) of this layer are most pronounced in the parts of the polar basin adjacent to the Eurasian continental shelf, over which passes the deepest part of the Atlantic current. After entering the polar basin the Atlantic waters press close to the continental shelf of Eurasia, a phenomenon which is explained by the rotation of the earth, under the influence of which all the waters and air currents in the Northern Hemisphere deviate to the right.

Besides the warm Atlantic waters flowing into the polar basin through the broad passageway between Spitsbergen and Greenland, the relatively cold waters of the Greenland Sea, having a negative temperature and a salt content

of about 3.49%, flow through this same passageway into the polar basin in the form of a deep current. These water masses fill a great part of the polar basin located between the lower limit of the Atlantic layer and the bottom. In the area of the drift of the "Fram" the temperature of these water masses is -0.7° or -0.9° and, in accordance with the observation of the Soviet drift station -0.5°.

The waters from the Pacific Ocean pour into the polar basin through the Behring Strait. However, in a quantitative sense, this flow of water is in no way comparable to the flow of water from the Atlantic Ocean.

The flow of the river waters, chiefly the Siberian rivers, plays a considerable part in the balance of water of the polar basin. It is due precisely to this flow that the upper layer of water of the polar basin, with a thickness of about 200 m, is freshened to a perceptible degree. This water, which is freshened and strongly cooled as a result of contact with the air, is usually called "polar water" (certain investigators--P. P. Shirshov, V. B. Shtokman--divide this layer into two water masses: Arctic surface water and intermediate water). As we have already seen, it is located in the polar basin over the Atlantic water.

Since the evaporation of water in the polar basin is extremely small and practically equal to zero, the whole mass of water flowing into the polar basin must somewhere flow out of it again. This removal of water takes place almost exclusively in the passage between Spitsbergen and Greenland, into which flows first of all "polar water," that is, the water of the upper layers of the polar basin. The movement of this water towards the Greenland Sea was first proved directly by the drift of the "Fram." In accordance with observations made during the time of this drift, the velocity of the current carrying the surface water from the New Siberian Islands to the passageway between Greenland and Spitsbergen is about 1 - 2 km a day (disregarding the influence of the wind).

The surface waters from the area located to the north of Greenland (in

accordance with the observations of Peary) and the waters from the area around the pole (in accordance with the observations of the Soviet drift station) also move towards the Greenland Sea. These observations show that the velocity of the constant stream moving from the pole into the Greenland Sea between parallels 89° and 84° amounts to about 1.8 km a day. As we approach the Greenland Sea the velocity increases and the stream also begins to press to the shores of Greenland, forming here the so-called East Greenland current, which is a direct continuation of the surface current of the polar basin (and which we may call a "sewer" or "drainage," a fact which was graphically shown by the drift of the "Severny Polius" (North Pole) station.

The drift of this station and also of a number of vessels squeezed in the ice blocks of the polar basin is shown on the attached scheme of the surface currents of the polar basin. The circular movement of the water to the north of Alaska, marked in a clockwise direction, is hypothetical; no direct observations have been made of the movement of the ice or the water in this part of the polar basin.

All the surface of the deep part of the polar basin is occupied by a thick ice sheet consisting chiefly of ice fields, forming stretches of 2 - 25 km or more. Under the influence of winds and currents these ice fields are in constant movement, sometimes piling over each other, breaking off along the edges and forming pack ice -- great blocks of ice lying at one time in a confused mass and at another time in the form of a ridge.

The main body of polar ice is formed in the cold season of the year in the shallow Siberian seas. The winds blowing from the continent and also the pressure of the currents carry the ice towards the north into the open polar basin, and in the spaces of clear water new ice is formed and carried in its turn towards the north. Hence, the seas of the Siberian continental shelf are, so to speak, the sources of the polar ice.

The ice blocks in the polar basin, coming under the influence of the general circulation of the surface waters, move in the direction of the passage-

way between Spitsbergen and Greenland. Usually, it takes several years for the ice blocks formed in the Siberian seas to travel from the polar basin into the Greenland Sea. During the time of its stay in the polar basin the ice undergoes certain changes, being transformed into the so-called Arctic pack, that is, large, thick ice fields developing over many years. The increase in the thickness of the ice in the polar basin takes place both by the freezing of the water to the lower surface of the ice and by the pack formation. However, the ice in the polar basin cannot continue growing forever; there are limits up to which the thickness of the ice can increase by the freezing of new ice from below. On the basis of calculations by Kh. Sverdrup, this natural limit for the extreme north part of the East Siberian Sea is 3.5 meters. The polar pack of the central Arctic reaches approximately this same thickness, as determined by measurements made during the time of the drift of the "Severny Polius" station.

The pack of the central Arctic is a great field, usually covered by sloping heaps. This smoothing of the relief of the surface of the field is explained by the fact that it has passed through more than one summer, and consequently the pack has been subjected to repeated summer melting. It is only along the edges of the pack fields of the central Arctic that we find ridges of young packs that have not yet reached great heights. In those fields which reflect the relatively quiet hydrometeorological regimen of the central Arctic it is not difficult to find areas suitable for the landing of airplanes. On the basis of observations of Soviet airplanes flying from Franz Josef Land to the Pole, the south edge of the pack of the central Arctic lay at latitude 85°.5 in May 1937. However, this limit, as shown by observations made in recent flights, is subject to great variations. During the time of the flight of I. I. Cherevichny, in 1941, to the north of Wrangel Island, the south limit of the Arctic pack was discovered at parallel 76 degrees.

The area of the pack of the central Arctic is touched on the south by an extraordinary pack of ice, consisting both of ice fields many years of age and of ice fields only one year old. The drift of the "Fram" took place in this

zone. The enormous accumulations of pack ice, which are characteristic of it, prevented Nansen from reaching the pole in 1895: the impenetrable blocks of ice forced him to turn towards the south on parallel 86° 14'. In the words of Nansen, this ice zone reminds us of a rocky desert covered with snow. It would be extremely difficult to find here an area suitable for the landing of an airplane.

Finally, still farther to the south, beyond the zone of the pack ice, there are the ice-floes of the bordering seas of the Arctic, consisting chiefly of one-year and two-year formations.

As we have recalled, all the masses of ice of the polar basin are moving slowly but not unswervingly in the general direction towards the passageway between Spitsbergen and Greenland, where the ice-floes come into the East Greenland current, by which they are carried to latitudes farther south. This current is practically the only artery along which the polar basin discharges its ice. The yearly quantity of ice brought by this current from the polar basin is estimated at approximately 10,000 cu. km.

THE SEAS OF THE EURASIAN CONTINENTAL SHELF

With the exception of the Barents Sea, these seas had not been investigated up until the October Revolution. After the continuous voyage of the "Sibiryakov" from Arkhangelsk to Petropavlovsk in Kamchatka in 1932, serious attention was given to the study of these seas, in accordance with the decisions of the Party and the Government for the inauguration of a North Sea route from the Atlantic to the Pacific. At the present time, as a result of the work of numerous Soviet expeditions, visiting yearly the waters of the Soviet sea route, our information concerning the shallow Siberian seas has been supplemented considerably.

The Barents Sea. This sea has great importance for the economy of the USSR due to the fact that it receives a powerful branch of the warm Atlantic current (the Gulf Stream)--the Nordkapp current, which exercises a moderating influence upon the climate of the northern areas of the European part of the

Soviet Union. The influence of the Nordkapp current is particularly great on the littoral areas; owing to this current Murman Oblast, far beyond the Arctic Circle, has an ice-free port. It is due to the presence of this same current that the Barents Sea has a rich fishing industry.

The Nordkapp current comes into the Barents Sea from the west, between Cape Nordkapp and Bear Island. The main axis of this current is around the 73d parallel. All the mass of water of the Nordkapp current moves in a southeast direction (and partly towards the east). Its velocity to the west of the meridian of the Kola Bay is about 5 cm per second. The quantity of Arctic water carried by this current into the Barents Sea is about 150 cu. km per day. The water of the Nordkapp current is characterized by a relatively large salt content, exceeding in the summer months 3.48% in the surface layer, and in the deeper layers, 3.5%. In all the rest of the areas of the Barents Sea the salt content is less; the minimum salt content is observed in the Pechora Sea, where in the summer it does not exceed 3.2%. The maximum winter cooling of the water of the Nordkapp current is observed in April, but even in this month the mean temperature (data concerning the temperature of the water is computed for a section along the meridian of Kola Bay between parallels 69°.5 and 72°.5) of all the thickness of the water of the Nordkapp current is around 3°. The maximum heating of the water takes place in September, when the mean temperature of the upper layer, with a thickness of about 50 meters, is equal approximately to 7°.5, and the temperature of all the layer is 5°.

In the course of the greater part of the year the waters of the Nordkapp current give off heat to the air. On the basis of an approximate estimate made by N. N. Zubovy, between the meridians of Nordkapp and Kola Bay each square centimeter of surface of the Nordkapp current gives off into the atmosphere about 120 kg/calories a year.

The velocity of the Nordkapp current and the temperature of the waters carried by it do not remain constant from year to year and are subject to sensible variations, which exert a great influense upon the climate and the

operations of the fishing industry. For the study of these variations in the Barents Sea, depth observations of the temperature and saltiness of the water are carried out regularly along the meridian of Kola Bay, the so-called "hydrological sections." In 1920 there was a sharp increase in the temperature of the water of the Barents Sea, and since this time the water has remained at a relatively high level. In view of this the climate of the Barents Sea and the area surrounding it has moderated perceptibly, and together with this there has been a sharp decrease in the quantity of ice in it. The increase in the temperature of the water also has its effect upon the organic world: warmth-loving marine organisms began to come into the Barents Sea, organisms which previously were not observed here (for example, codfish appeared in paying quantities) in the northeast part of the sea, near the northwest shores of Novaya Zemlya).

The branch running close to the western shores of Novaya Zemlya in a northeast direction and known by the name of the Novaya Zemlya warm current is a direct continuation of the Nordkapp current. Fishing equipment used in Norway and other objects from the west are cast by this current on the shores of Novaya Zemlya. On the small islands near the northwest shores of Novaya Zemlya one found beans Entada gigalobium brought from the West Indies by the Gulf Stream.

Atlantic water comes into the Barents Sea not only between Nordkapp and Bear Island but also from the northwest (between Spitsbergen and Franz Josef Land) and from the northeast between Franz Josef Land and Novaya Zemlya). In the last two passageways the Atlantic water flows into the Barents Sea in the form of deep currents; hence, the flow of these waters does not exercise such an influence upon the climate as the Nordkapp current carrying warm Atlantic water on the surface of the sea.

The cold polar waters are brought into the Barents Sea by the currents flowing from north to south along the eastern shores of Spitsbergen and Franz Josef Land. As a result of the meeting of these cold currents with the Nordkapp current and its branches there is formed in the central part of the Barents Sea a number of large water eddies, in the majority of which the water moves in a

counter-clockwise direction.

Owing to the influence of the warm Nordkapp current, the south part of the Barents Sea is free of ice throughout the year. The mean position of the south limit of ice-floes in the Barents Sea in the different months is shown on the attached map. The maximum development of the ice cover is reached in April, when the ice occupies about three-fourths of all the surface of the sea. The edge of ice occupies its most northerly position at the beginning or the middle of September, after which, as a result of the formation of new ice, the edge begins to move towards the south. After 1920, that is, after the warming up of the Barents Sea, it was often observed to be entirely free of ice by the end of the summer.

In the Barents Sea we nearly always encounter ice that is less than a year old. Here the thickness of such ice usually does not exceed 3/4 - 1 meter (if we except the pack ice). In certain years we find in the Barents Sea ice blocks that are several years old, brought chiefly from the extreme northwest part of the Kara Sea.

Sketch on page 24. South limits of ice blocks in the Barents Sea (1921-1938).

Icebergs, that is, large floating pieces that have broken from the glaciers, are found in the Barents Sea in rather large numbers near the shores of Franz Josef Land and Spitsbergen and in a much smaller number near the northwestern shores of Novaya Zemlya. Sometimes the icebergs are carried by the winds far into the south of the Barents Sea, right up to the shores of Murman Oblast; but this is a very rare phenomenon.

The Kara Sea. The water masses of the Kara Sea are made up of the following:

1) the water of the Barents Sea, coming in chiefly from the north, rounding the cape of Zhelaniya, and in smaller quantities through the straits of Karskie Vorota and Yugorski Shar;

2) the Atlantic waters of the polar basin, coming into the Kara Sea from the north in the form of deep currents, and

3) the river waters brought by the Ob and the Yenisei and other less important rivers. The water masses just enumerated are subjected in the Kara Sea to a partial mixing, as a result of which there is formed a fourth basic type of water--the water proper of the Kara Sea.

In the southwest part of the Kara Sea, to the south of parallel 74° N, we observe a circular movement of the water masses, and near the shores of Novaya Zemlya the current moves from the north to the south, and near the shores of Yamal it moves in the opposite direction. The flow of the continental waters of the Ob-Yenisei basin (the yearly discharge of the Ob amounts to about 440 cubic kilometers, and the yearly discharge of the Yenisei amounts to about 410 cubic kilometers) gives rise to a current which carries the surface waters of the Kara Sea into the polar basin. One of the branches of this current, passing to the west of Vize Island, was given the name of St. Anna current, because the schooner St. Anna, crushed in 1921 by icebergs on the western shores of Yamal, in 1915 was carried by this current into the polar basin. The eastern branch of the Ob-Yenisei current moves towards the western shores of Severnaya Zemlya.

The waters of the Ob-Yenisei current are characterized by a relatively

high summer temperature (in the Ob-Yenisei region of the Kara Sea the temperature of the surface layer is about 6°), a very low salt content (in this same region it is .5 -- 1.5 percent) and a brown color, which gradually changes into a greenish color as we move towards the north. The thickness of the layer of the Ob-Yenisei waters is not great -- 10 to 15 meters. Under this layer there is cold water with a high percentage of salt and with a temperature remaining below zero the year round. It is only in those places in the Kara Sea reached by the Atlantic waters (that is, in the deep channels or troughs cutting into the Kara Sea from the north) that the temperature of the water reaches 1° -- 2° at a depth of about 200 meters.

In the winter and spring all of the Kara Sea is occupied by ice blocks. It is only here and there, chiefly under the influence of the wind, that we find spaces of water temporarily clear of ice, the presence of which may be judged from afar by the dark "watery cloud" hanging over the space. In the cold season of the year the ice freezes close up to the shores and remains immovable; this is the so-called land-floe. The width of it in the Kara Sea varies from several hundred meters to 10 or more kilometers. Usually the isobath of 25 meters is taken as the limit of the spread of the land-floe. Beyond the land-floe there are ice floes, which, under the influence of the current and in particular of the wind, are in continuous movement. In the main, the movement of the ice floes in the Kara Sea is towards the north, that is, towards the open polar basin.

The maximum thickness of the ice in the Kara Sea is reached in May. During this time the thickness of the level ice not subjected to packing amounts to 1.5 -- 2 meters.

The melting of the ice cover starts when the temperature of the air rises above zero and in the Kara Sea it takes place in a rather energetic manner, especially in the southwest part, which, in the period of the warming up of the Arctic (that is, after 1920), is generally entirely free of ice by the beginning of September. In the second half of August, the probability of encountering icebergs in this part of the Sea is still great, being about 60% near the

shores of Novaya Zemlya and about 30% near the shores of Yamal. This lack of uniformity in the distribution of ice in the Sea exemplifies a rule that is common for all of the Arctic, namely, on the eastern shores of islands and peninsulas the Sea is more icy than on the western shores. This is explained by the influence of the rotation of the earth, as a result of which the waters moving from the south to the north (that is, the warm water) and deviating to the right, press towards the western shores, and the waters flowing from the north to the south (that is, the cold waters), also deviating to the right, press against the eastern shores.

A large part of the Kara Sea to the east of the 80th meridian usually has icebergs, either large or small, throughout the summer. If these icebergs, moved by the wind, press against the shore, they unite and then constitute a very serious impediment to navigation. Due to the general warming up of the Arctic in recent times, periods have been observed when the northeast part of the Kara Sea was almost completely free of ice (1932, 1935, 1938).

As a rule the ice regimen of the Kara Sea is distinguished by its great variability; in separate years the condition of the ice in this Sea differs widely. In the main it is determined by the meteorological conditions. The condition of the ice in the Kara Sea is influenced to a certain extent by the discharge of the rivers, which is also subject to variations from year to year. The warmth brought into the Kara Sea by the rivers can melt a meter of ice over an area of about 100,000 square kilometers; that is, approximately 1/8 of all the sea.

A large part of the ice of the Kara Sea is not over one year old. This is explained on the one hand by the intensive melting of the ice and on the other hand by the fact that the ice of the Kara Sea, moving as a rule towards the north, is carried out of the Sea. In the Kara Sea icebergs many years old are usually found only north of the 79th parallel, and also in the extreme eastern part of the Sea (to the east of the 90th meridian).

For a long time the ice-floes of the Kara Sea were regarded as unsurmountable

obstacles for the establishment of regular summer sea communications between Europe and the mouths of the Ob and Yenisei, and it took the voyages of A. Nordenskjöld and I. Viggins in the 70's of the last century to prove definitively the untenableness of this opinion. However, practical navigation over a sea route up to the Ob and Yenisei did not take place until much later--when the Soviets came to power. This was achieved by the employment of ice cutters for accompanying the freighters, by setting up a number of meteorological radio stations on the shores of the Kara Sea, by the organization of airplane ice reconnaissance, and by the study of the general regimen of the Kara Sea. Through these measures navigation in the western part of the Kara Sea (between Novaya Zemlya and the Gulf of Yenisei) is possible at present for not less than 2½ months (from the beginning of August to the middle of October).

The systematic work carried out to make possible navigation in the eastern part of the Kara Sea (between the Gulf of Yenisei and Vilkitsy Strait) was started after the expedition of the "Sibiryakov" (1932). The ice conditions in this sector of the North Sea route are much more serious than in the western part of the Kara Sea; nevertheless, navigation experience showed that with proper technical equipment regular sailing is possible in the eastern part of the Kara Sea for about 1½ months. Still more unfavorable ice conditions are encountered in Vilkitsky Strait, which, being located on the 78th parallel, is not only the most northerly but also the most difficult sector of the Northern Sea route.

The Laptev Sea. The most outstanding feature of the hydrological regimen of the Laptev Sea is the enormous discharge into this Sea of fresh water brought by the Yana, Lena, Olenek, Anabara and Khatanga Rivers. The total discharge of river water into the Laptev Sea is about 600 cubic kilometers a year. The main mass of the water of the Lena, after leaving the delta of the river, moves towards the northeast, in the direction of the New Siberian Islands. The freshening influence of the Lena shows itself distinctly in the surface layer of the Sea, even at a distance of 500 kilometers from the delta. As a result of the

mixing of the river water large areas of the Laptev Sea have a brownish color. Along with this we very often find timber brought by the rivers, the so-called "plavniks," which at certain places on the shore of the Laptev Sea is piled up in enormous quantities.

The water that is well freshened by the discharge of the rivers (having in August a rather high temperature of about 5 -- 6 degrees) forms in the Laptev Sea only a very thin layer of about 10 meters. Below this layer the water has a temperature below zero and a much higher percentage of salt.

In the eastern part of the Laptev Sea we observe a general movement of the water from the south to the north, while in the western part of the Sea, in accordance with the general law, based on the influence of the rotation of the earth, the water flows from the north to the south. In addition to the water of the extreme northwest part of the Laptev Sea, the water of the Kara Sea, brought through Vilkitsky Strait, also participates in the formation of the cold current near the Taimyr Peninsula. The East Taimyr current carries towards the south (in a very small numbers) icebergs broken off from the ice fields of Severnaya Zemlya.

The peculiar hydrological conditions observed in the extreme southwest part of the Laptev Sea, in the area of Khatanga Bay. Here the strong flood and ebb tides cause a great periodic variation in the level of the sea (with a range up to 2 meters), as well as strong currents. The flood and ebb tides of the Khatanga area are the largest to be found on the stretch of the North Sea route.

In the cold season of the year the Laptev Sea has ice blocks, which in the extreme eastern part of the sea are stationary. On the meridian of the mouth of the Yana River the width of the land-floe reaches 500 kilometers. To the north of the New Siberian Islands the limit of the land-floe is approximately 15 -- 40 kilometers from the shore. When the winds are blowing from the continent, there are large spaces of clear water (clear of ice) between the north limits of the land-floe and the drifting ice, spaces which are known as the "Siberian polynias," a condition which gave rise to the legend of a

"polar sea free of ice" stretching almost to the pole. When there is little wind, the Siberian "polynia" is quickly covered with new ice, and with winds blowing from the sea the drift ice again approaches close to the land floe and the "polynia" disappears.

Currents in the opposite direction in the western and eastern parts of the Laptev Sea cause a similar distribution of the ice floes. To the west of the New Siberian Islands, the Sea, under the influence of the relatively warm water, brought from the south (the Lena current), is entirely free of ice by the end of the summer. However, in the summertime, as a rule, a large mass of ice, moving far towards the south in the form of a tongue, hugs the east shore of Taimyr. This massif is fed not only by ice coming from the extreme northwest part of the Laptev Sea but also by the ice of the Kara Sea, brought in the summer in an almost continuous flow from Vilkitsky Strait. The east Taimyr ice massif sometimes creates certain difficulties for navigation; in the rest of the Laptev Sea, however, vessels can usually navigate along the North Sea route without encountering any obstacles.

The East Siberian Sea. The hydrological regimen of the East Siberian Sea resembles a great deal the regimen of the Laptev Sea. Even here the sea water is freshened up a great deal as a result of mixing with river water (Indigirka, Alazen, Kolyma), even though the quantity of river water flowing into the East Siberian Sea (about 156 cubic kilometers a year) is only a little more than $\frac{1}{4}$ that coming into the Laptev Sea. A certain part of the river water goes through the Strait of Dm. Laptev (and a part through Sannikova Strait) into the Eastern Siberian Sea, freshening to a considerable degree the water of the extreme western part of the latter.

During the navigation period (end of July -- end of September) the part warmed up most is the littoral part of the East Siberian Sea. The temperature of the water in this zone usually stays above zero, and at the end of August and in September the western part of this zone (to the west of the mouth of the

Kolyma) is either entirely free of icebergs, or if they are present at all they are few in number. The width of this littoral zone, which is very favorable for navigation, is about 100 kilometers to the west of the Kolyma; in the eastern part of the Sea it is much narrower. In the south part of the East Siberian Sea, the thickness of the layer of well-freshened water with a temperature above zero degrees is very small: it does not exceed 10 meters, and at places it is only 5 meters.

In the East Siberian Sea, to the north of the relatively warm littoral zone, there is water the temperature of which is generally below zero from the surface to the bottom even in summer. This part of the Sea generally has icebergs, which to the east of the meridian of the Kolyma are characterized by their great continuity and constitute a difficult obstacle even for ice cutters. To the east of Cape Sholagskl the massif of difficult icebergs of the East Siberian Sea, even in the middle of summer, many times reach close up to the shores of the continent, as a result of which the conditions for navigation in this area are highly unfavorable in certain years.

Picture, page 30. An Arctic landscape.

The Chukchee Sea. The warm waters coming in from the south through the Bering Strait have a great influence upon the regimen of the Chukchee Sea. In August about 30% of these waters have a temperature of more than 7°. As a result of the coming in of this water the south part of the Chukchee Sea in a direction approximately south of the line Koliuchinskaya Gulf -- Cape Hope in Alaska is characterized by relatively favorable temperature conditions: here the whole thickness of the water (the depth of the sea being 40 -- 50 meters) has a

temperature above zero in the summer.

The main mass of warm Bering water, when it comes from the Bering Strait, moves towards Alaska, but at the same time a certain part of this water flows towards the northwest, in the direction of so-called Long Strait (between Wrangel Island and the continent).

Picture, page 31. Continuous broken up ice in Chukotskiy (Chuckchee) Sea.

The cold waters come into the Chuckchee Sea from the north between Wrangel Island and Herald Island, and a large quantity also comes from the northwest, from the East Siberian Sea. The water coming in from the northwest presses towards the Chuckchee littoral, forming here a cold current, reaching up to the Bering Strait itself and penetrating into it in the form of a narrow stream washing Cape Dezhneva. As a result of the meeting of the water of the cold Chuckchee current with the water of the warm Bering current there are formed in the Chuckchee several large circular movements of water. The distribution of ice in the Chuckchee Sea depends to a considerable degree upon the scheme of currents given above. In the summer the area adjacent to the Bering Strait is usually free of ice. Under the influence of the warm Bering waters, a "gulf" (of ice-free water) extends from this broad space of ice-free water in a northwest direction, cutting into the icy area of Long Strait. The southeast current, moving near the Chuckchee littoral, oftentimes carries thick masses of ice reaching sometimes close to Bering Strait itself.

From the standpoint of ice, the littoral of the Chuckchee Peninsula to the east of Cape Shelagski is one of the most difficult sectors of the North Sea route, in spite of the fact that it is located farthest south. This is explained by the absence, to the north of the Chuckchee littoral, of large islands which

could serve as protective screens against the icebergs (Wrangel Island is too small for this purpose), and also of large rivers. On the Chukchee littoral there has been forced laying up of vessels for the winter more often than in other areas; and here too vessels have suffered serious damages (loss of the "Cheliuskin" in 1934, loss of the screw propeller of the "Sibiryakov" in 1932, and others).

CLIMATE

In the high geographical latitudes of the Arctic, the sun, even in summer, rises very little above the horizon, and in the wintertime there is a certain period when it does not show itself at all above the horizon. At the pole itself the height of the sun never exceeds 25°.5. Due to the low position of the sun, the total amount of solar radiation in the Arctic cannot be great. For example, in latitude 80 degrees (that is, the latitude of the south part of Franz Josef Land) each square centimeter of horizontal surface can obtain during the year, as a result of solar radiation, 65,700 small calories, whereas in latitude 50 degrees the amount of heat received on this area is equal to 105,700, and at the equator it is equal to 186,500 (In the computation of the total heat of solar radiation we take 0.8 as the coefficient of transparency). In reality, the quantity of heat received from solar radiation in the Arctic is much less than that given, because the great cloudiness and the frequent fogs, which characterize the Arctic intercept (as shown by observations at Spitsbergen) about 80% of the possible solar radiation. Consequently, in the Arctic only about 13,000 small calories reach the earth's surface, that is, only 1/5 of that which reaches the earth's surface at latitude 50 degrees.

The extremely favorable conditions of "solar climate" compensate to a certain degree, in the summer, for the great quantity of dissipated radiation, explained perhaps by the prevalence in the Arctic of thin, loose clouds. As shown by actinometric observations carried out at the polar stations of the Soviet Arctic, the total dissipated radiation during 24 hours, in the spring

and summer, oftentimes amounts to 300 -- 400 calories -- an amount never observed in areas much farther south, for example at Slutsk (Leningrad Oblast). In the summer months, on Franz Josef Land, the quantity of heat dissipated by radiation is greater than at Kara Dag (Crimea).

Owing to the great amount of dissipated heat, the total radiation in the Arctic in the spring and summer is considerable. For example, from April to August the total radiation in Tikhaya Bay of Franz Josef Land was greater in 1934 and 1935 than at Slutsk, and in separate months it was only a little less than in Kara Dag.

Picture, p. 33. Rudolph Island.

Excepting astronomical causes, the most important climate-forming element in the Arctic is the fact that a great part of it is covered with water. Hence, for astronomical reasons the climate of the Arctic is polar, and the presence of a large polar basin makes it a polar sea.

The chief characteristic of every marine climate is the small range in the yearly variations in the temperature of the air, a condition which in its turn is caused by the relatively warm winter and cool summer. In the Arctic the moderating influence of the sea in the wintertime is weakened to a certain extent by the fact that it is covered with ice. However, the ice cover is not an obstacle which can stop entirely the exchange of heat between the sea and the air; however, in the "polynias," and canals formed in the polar basin and its bordering seas this exchange of heat takes place very vigorously even in the cold season of the year, because of the great difference between the temperature

of the water (about -2 degrees) and the temperature of the air (about -30 degrees). The cooling influence of the sea in the warm time of the year is particularly great, because the large masses of ice, not having sufficient time to melt in the summer, absorb large quantities of heat when they melt.

The influence of the sea on the temperature of the air in the polar littoral of the USSR is well illustrated in Table 1, in which, for a number of points located on the Yenisei and Lena at various distances from the sea, we have given the mean monthly temperatures of the air in December and July, and also the value of the yearly range (that is, the difference between the temperatures of the warmest and the coldest months).

Table 1 (Page 34)

The mean monthly temperatures of the air in December and in July and the values of the yearly ranges:

Points	North Latitude	East Longitude	Temperature of the air		Range
			December	July	
Dikson	73°30'	80°25'	-23°,5'	4° 6	30°5
UST-Yeniseisk	69 40	84 24	-25 0	12 4	39 6
Dudinka	69 24	86 04	-25 7	13 0	40 6
Igarka	67 27	86 36	- 28 5	14 6	45 8
Tiksi	71 39	127 47	-30 0	9 2	38°2
Bulun	70 45	121 55	-35 3	12 7	51 8
Viliuisk	63 46	129 43	-37 3	16 5	57 9
Yakutsk	62 01	129 05	-40 0	19 0	62 5

As we can see from this table, in December the temperature of the air drops as we go away from the littoral; that is, in this time of the year the distribution of the temperatures of the air takes place in accordance with a rule appearing

appearing at first glance to be paradoxical, namely, the farther we go towards the south the colder it gets. In July we have the reverse phenomenon: upon approaching the sea the temperature drops sharply.

The temperature change is particularly great close to the littoral zone itself. This is evident from the following mean January temperatures for three stations on the shores of Kola Bay, in the case of which two extremes are only 40 kilometers apart: the village of Polyarnoe -- 8 degrees; Murmansk -- 10 degrees; Kola -- 11°,5.

At the village of Polyarnoe, located closest of all to the mouth of the bay, the January temperature is 2°,7 higher than at Kola, lying at the head of the bay. The temperature at Murmansk is in keeping with its intermediate position.

The influence of the warmth of the sea water is explained by the fact that the "pole of cold" lies not in the Arctic but at Oimyakon in Yakutia (Yakutsk Province) (63° 16' north latitude), that is, at a distance of 5,000 kilometers from the geographical pole. The mean temperature of January (the coldest month) is -51 degrees at Oimyakon, whereas at the North Pole this temperature is assumed to be equal to -40 degrees.

The third important factor going to make up the climate of the Arctic is the distribution of the pressure of the air, which causes the prevalence of some kind of an air current. The area of relatively stable and low barometric pressure in the north Atlantic , known as the "Iceland minimum," is of particularly great importance in determining the climate of the Arctic. From it a trough of low pressure extends towards the northeast and east, reaching in the wintertime up to the Taimyr Peninsula, and in the fall as far as the New Siberian Islands. This trough of low pressure, which is the result of the frequent passage of deep cyclones
/over the bordering seas of the western half of the Soviet Arctic, causes a flow into the Arctic of relatively warm and moist masses of Atlantic air.

Just as the "Iceland minimum" is present in the North Atlantic, so in the north of the Pacific there is a semi-stationary "Aleutian minimum." The influence of this baric formation upon the climate of the Soviet Arctic is much less than

the influence of the "Iceland Minimum" and is limited almost exclusively to the Chuckchee Sea and the adjacent parts of the East Siberian Sea.

Between the aforementioned baric minimums, in the cold time of the year, there is the winter Siberian anticyclone, in the area of which there is formed some very cold air. Since the atmospheric pressure is less to the north of the Siberian anticyclone, this cold air flows in the direction of the bordering seas of the Arctic, making possible in their littoral zone a relatively low temperature. As an example of the cooling influence of the Siberian anticyclone on the climate of the littoral areas of the Soviet Arctic we may give the following mean temperatures of the air at Kazache (mouth of the Yana River) in the winter with winds from various directions.

Sketch, page 36.

Legend: Distribution of the mean pressure of the atmosphere (in millibars) in the Arctic, in winter (N. N. Zubov) and the direction of the equinoctial wind.

	N	NE	E	SE	S	SW	W	NW
Wind.....								
Temperature of the air.....	-31.6	-32.5	-36.2	-36.6	-35.3	-36.0	-33.7	-31.9

As we can see, in the wintertime, the winds at Kazache with a south component (SE, S, SW) are perceptibly colder than winds with a north component (NW, N, NE), blowing from the direction of the polar basin.

Sketch, page 37.

Legend: Distribution of the mean atmospheric pressures (in millibars) in the Arctic in the summertime (by N. N. Zubov) and the direction of the equinoctial wind.

In the warm season of the year there is no Siberian anticyclone, and it is replaced at this time by an area of relatively low pressure, as a result of which the air flows chiefly from the direction of the polar basin towards the continent, that is, in a direction contrary to that which is observed in the wintertime. Hence, the change of the winds in the course of the year, on the littoral of the Soviet Arctic, has a monsoon character. In summer, on the shores of central Siberia, the winds are accompanied by the reverse temperature effect in comparison with the winter. This can be seen from the following data showing the mean temperature of the air/with various winds. in summer at Kazache,

Wind	N.	NE	E	SE	S	SW	W	NW
Temperature of the air	6.2	6.1	9.3	11.8	13.4	12.3	7.2	6.4

The series given illustrate very well the cooling effect of the Arctic seas in the summer.

In summer and in winter cold currents of air prevail in the polar littoral area of Yakutia (Yakutsk Province).

In winter and especially in the spring, another anticyclone located over the central part of the polar basin exercises a substantial influence upon the climatic conditions of the Arctic. In January, February, and March the polar anticyclone is usually absent as an independent formation, being replaced by a ridge of high pressure, which connects the "Siberian maximum" with the maximum analogous to it over North America. A characteristic of the polar anticyclone is that it is much less stable than the Siberian, and sometimes the central Arctic

becomes the arena of rather vigorous cyclonic activity, observed both during the time of the drift of the "Fram" and of the Soviet drift stations.

Fall (in the present survey of the climatic conditions of the Arctic we have adopted the usual conventional division of the year into four seasons: fall — from September to November, winter — from December to February, spring — from March to May, summer from June to August). The quantity of marine ice in the Arctic reaches its yearly minimum at the beginning of September, after which new ice begins to form. Hence, at the beginning of fall the area of open water in the Arctic is at its maximum. Over the spaces in direct contact with the air there takes place a constant radiation of heat from the sea into the atmosphere. As a result of the great thermic capacity of the water, the quantity of heat passing into the atmosphere is very great and it greatly retards the autumn drop in the temperature of the air in the Arctic. This can be seen readily from Table 2.

Table 2 (Page 38)

Points	September — October	October — November
Bear Island (Medvezhii)	-3°.0	- 4°.7
Malye Karmakuly	-5 6	- 6 5
Dikson Island	-8 3	-10 [illegible]
B. Lyakovski Island	-9 3	-12 6
Cape Shmidt	-8 7	-10 0
Wrangel Island	-6 2	- 8 3

in which we have given the drop in the temperature of the air from September to October and from October to November for 6 polar stations (given in order from west to east).

From Table 2 we see that the fall drop in temperature takes place most slowly in the extreme western and eastern parts of the Soviet Arctic, that is, at the places where the influence of the ocean makes itself felt most strongly. In the central areas of the Soviet Arctic, the drop in the temperature of the

air in the fall takes place rather fast, being most rapid in the New Siberian Islands. The latter circumstance is explained both by the weakening at this place of the influence of the Atlantic and Pacific Oceans and by the nearness of Yakutia, with its harsh continental range of temperatures. As an example of the character of the latter we may say that in Verkhoyansk the drop in the temperature of the air from September to October is $12^{\circ}.2$ and from October to November $22^{\circ}.2$.

In September the lowest mean monthly temperature of the air (about -10 degrees) is observed in the central part of the polar basin. During this same time the temperature still remains above zero degrees in the Barents Sea (to the south of parallel 75 degrees, in the south part of the Kara Sea, in the area of the delta of the Lena, in the southern part of the East Siberian Sea and over almost all of the Chukchee Sea. As early as October, the mean monthly temperature in all of the Soviet Arctic (with the exception of the narrow zone of the Barents Sea adjacent to the Murman littoral) is below zero, and the lowest temperature (about -20 degrees) just as in September, is reached in the central part of the polar basin. As early as November the area of the minimum temperature is on the continent: in Verkhoyansk the mean temperature of this month is $-36^{\circ}.8$, whereas in the area of the North Pole it is only $-32^{\circ}.5$ (hypothetically). On the basis of the temperature conditions even November, in the Arctic, is a real winter month, and is reckoned as a fall month only on the basis of the formal division of the year into four seasons of equal duration, adopted in meteorology. In a great part of the Soviet Arctic the mean temperature of November is less than -20 degrees, and it is only to the west of meridian 80° East and to the east of meridian 170 E that the influence of the Atlantic and Pacific Oceans keeps the temperature from falling so low. On Bear Island (Medvezhii) on the western limits of the Barents Sea, the mean temperature in November is equal to only -6°, on Uellen in the Bering Strait it is -12°.

Due to the fact that fall in the Arctic starts abruptly there is an increase in the difference between the temperature of the air over the open sea and over

the continent; the state of the atmosphere is more disturbed in comparison with the conditions in summer; cyclonic activity increases; and the velocity of the winds increases. The increase in the velocity of the wind beginning with fall can be seen from the adjacent sketch, on which we have represented the mean monthly velocities of the wind for two polar stations (Tikhaya Bay, Malye Karmakuly). During the time of the drift of the "Mod" the maximum mean monthly velocity of the wind in the East Siberian Sea was observed in the fall; usually, however, the maximum force of the wind in the Soviet Arctic occurs in the winter months.

Diagram, page 40.

Legend: Yearly variation in the velocity of the wind. 1. Meters per second. 2. M. Karmakuly 3. Tikhaya Bay.

Along with the increase in the mean velocity of the wind in the fall, beginning with October in particular, there is also an increase in the number of storms, which can be easily seen from Table 3.

Table 3, (Page 40)

Number of days with stormy winds greater than 15 m/sec.

Points	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Tikhaya Bay	10	10	7	4	3	2	2	2	4	7	11	10
Malye Karmakuly	18	16	15	12	10	8	8	5	8	12	14	15
Wrangel Island	8	6	5	4	2	1	3	2	5	5	5	7

Since in the Soviet Arctic the snow cover is generally present as early as the end of September or the beginning of October, the coming of fall indicates not only the beginning of the period of storms but also of snowstorms. The snowstorm is one of the most characteristic features of the climate of the Arctic. The finely ground-up snow of the snowstorm is snowy dust capable of penetrating into the smallest openings. During snowstorms objects only a few meters away are invisible. Snowstorms occur in the Soviet Arctic very often in the cold period of the year, as shown by the data of Table 4.

Table 4 (Page 41)

Number of days with snowstorms.

Points	IX	X	XI	XII	I	II	III	IV	V	VI
Tikhaya Bay	7	14	17	15	16	18	20	16	14	6
Matochkin Shar	2	14	19	18	21	18	21	19	17	6
Dikson Island	1	14	18	18	19	20	20	18	15	5
B. Lyakhov Island	4	14	13	14	15	13	16	14	16	2
Wrangel Island	6	11	15	14	16	14	14	12	8	2

As we can see from Table 4, half of the days of the cold season of the year have snowstorms. Such frequent occurrence of snowstorms constitute a plague of the Arctic climate. In the central part of the polar basin, due to the less disturbed condition of the atmosphere, snowstorms are much rarer and are not so severe as in the bordering seas of the Arctic.

The strong winds prevent the measurement by means of a rain gage, of the amount of precipitation falling in a solid form, because a considerable part of the snow is blown out of it. The rain gages installed in the Soviet polar stations generally show a greater quantity of precipitation in the summer. Apparently, the only explanation for this is that in summer a considerable amount of precipitation falls in the liquid form and, hence, is not blown out of the rain gage. Since in the Soviet Arctic precipitation falls most frequently in the fall (Table 5), it is very likely that the maximum precipitation occurs during this season of the year

and not in the summer.

Table 5 (Page 41)

Number of days with precipitation

Points	Fall	Winter	Spring	Summer
Tikhaya Bay	43	38	33	38
Malye Karmakuly	51	46	38	38
Dikson Island	45	27	30	40
B. Lyakhov Island	54	23	13	28
Wrangel Island	29	22	21	29

In the western part of the Soviet Arctic, the air contains a relatively greater quantity of moisture, due to the nearness of the oceans; hence, the precipitation in this part of the Arctic is relatively abundant. For example, on the northwest shore of Novaya Zemlya, the yearly quantity of precipitation is estimated at 450 mm. Approximately the same quantity of precipitation falls on the south shore of Franz Josef Land. This makes possible considerable glaciation on the islands in the extreme western part of the Soviet Arctic. Farther to the east the quantity of precipitation is much less. Thus, on Dikson Island, the precipitation is about 200 -- 230 mm a year, and on the New Siberian Islands it is still less.

In September, at the majority of the polar stations located to the west and east sides of the Soviet Arctic, the chief form of the precipitation is still rain, while as early as October there is a decided predominance of solid precipitation throughout the Arctic. Even though rain is possible in November in the regions of the Arctic adjoining the Atlantic and Pacific Oceans, it constitutes a rather rare phenomenon (if we except the south part of the Barents Sea and the south island of Novaya Zemlya). The cloudiness in the Arctic in the fall is very great, and at the majority of the Soviet polar stations the maximum for the yearly variation drops during the first half of the fall. In September the probability of an overcast sky in the greater part of the Soviet Arctic

exceeds 80%, reaching at certain places (for example, at Cape Shmidt) 90%. In In November, when the general character of the weather becomes wholly winter in character, we observe a perceptible decrease in cloudiness in comparison with the preceding months.

The beginning of fall in the Soviet Arctic is characterized by the frequent occurrence of fog. Even though fogs occur more rarely in September than in July and August, the number of days with fog in this month is still 10 -- 15 in a considerable part of the Arctic.

Winter. Winter in the Arctic, due to the influence of the sea, is warmer than in northeast Siberia. The lowest mean monthly temperatures of the air are observed in winter in the central part of the polar basin, where the temperature in January and February remains on the average below minus 40 degrees. In the bordering seas the lowest temperatures are recorded in the winter in the Laptev Sea and in the East Siberian Sea. The mean temperature of the air in January and February remains below -50° only in the New Siberian Islands. In Matochkin Shar (the eastern mouth), located approximately on the same parallel of latitude as the B. Lyakov Island, the temperature in the wintertime, due to the influence of the Barents Sea, is approximately 10° higher than in the New Siberian Islands.

In the central part of the continental littoral area of the Soviet Arctic, the temperature of the air in separate cases drops below -50°; on the islands, however, such low temperatures constitute a very rare exception. For example, in Novaya Zemlya a temperature of less than -50° has been recorded only once, up until the present time. During the time of the drift of the "Mod," the absolute minimum temperature of the air in the New Siberian Sea was -43°.5, and during the time of the drift of the "Fram" the temperature dropped to -50°. This is the lowest temperature so far observed in the open part of the polar basin.

The layer of air close to the surface of the earth, forming the so-called "film of cold air," the thickness of which amounts on the average to 360 -- 560 meters in the wintertime, undergoes extensive cooling.

One of the most characteristic features of the winter temperature regimen of the Soviet Arctic is constituted by the extremely sharp variations in the temperature of the air caused by the intrusion into the high latitudes of warm air masses from the oceans (chiefly from the Atlantic), in exchange for which cold masses of air come from the central polar basin or from Siberia. It is not rare that high temperatures are recorded on Novaya Zemlya, where thaws are possible in all of the winter months. In Matochkin Shar such high temperatures as plus 4° and plus 5° have been recorded in the middle of winter. We may get an idea of the extent of the periodic ranges of temperatures of the air in the western part of the Soviet Arctic from the observations made in Folka Bay (western shore of Novaya Zemlya 76° N), where a temperature of +1°.0 was observed on 10 January 1913 and -50°.2 on the 28th of this same month.

The non-periodic variations of the temperature of the air in wintertime in the Arctic are very great, while the periodic are very small. There is practically no daily variation of temperature in the wintertime in the high latitudes of the Arctic, and on the average the temperature is the same in the daytime that it is at night. In certain areas of the Arctic the night, averaged for the month, is warmer than the day. The amplitude of this variation, however, is very small; it amounts to only several tenths of a degree and sometimes even less.

Even though the winter temperature of the air even in the Arctic does not fall so low as in the northeastern part of Siberia, still the Arctic winter is more severe than the Siberian. This is explained by the fact that in Siberia the heavy freezes are accompanied by little wind, whereas in the Arctic there are oftentimes heavy winds with low temperatures. One of the most windy places of the Soviet Arctic is Malye Karmakuly on the west shore of Novaya Zemlya, where the mean velocity of the wind in the wintertime is 11 m/sec. The maximum velocity of the wind is observed in the Arctic in the sold season of the year, because at this time the temperature gradients (and, hence, also the baric) are at a maximum.

Wind velocities of 40 m/sec in Novaya Zemlya and Franz Josef Land are not

rare, and in Matochkin Shar the anemograph once recorded an average hourly velocity of 47 m/sec. In the extreme eastern part of the Soviet Arctic the velocity of the wind is also very high at times, particularly on Wrangel Island, where hurricane winds with a velocity of more than 40 m/sec have been observed on repeated occasions.

The winter storms in the Arctic are sometimes of long duration. For example, on Dikson Island there was a winter storm lasting for 13 days in succession. The Arctic is the typical country for storms and snowstorms, and it is precisely the storms which give to the climate of this region of the earth such a severe character.

Table 6 gives the values for the so-called "rigorous weather" from January to March, computed on the basis of the formula of Bodman, which expresses the weather as a function of the temperature of the air and the velocity of the wind.

Table 6 (Page 44)

Points	Severity of the weather
Tikhaya Bay	5.2
Matochkin Shar	5.2
Malye Karmakuly	6.1
B. Lyakhov Island	4.8
Wrangel Island	5.0
Verkoyansk	3.1
Leningrad	2.3

As we can see from Table 6, in the northeastern part of Yakutia, where the mean temperature of the winter is -47°, the weather is less severe than at Malye Karmakuly in Novaya Zemlya, where the winter temperature is only -12°, but where on the other hand severe hurricanes rage.

Picture, page 45. Antenna wrapped in rime.

It is necessary, moreover, to note that in the majority of places in the Soviet Arctic, calm weather is observed in the wintertime fairly often, along with strong winds. For example, in Matochkin Shar, on B. Lyakhov Island, and at Cape Shmidt the probability of a calm in the wintertime is 18%. In the open parts of the polar basin the probability of a calm in the wintertime is much less (during the time of the drift of the "Fram" and the "Mod" it was only 2 -- 3%.

The cloudiness in the wintertime is not so great as in the fall, and the quantity of precipitation is also less. The latter generally falls in the form of small separate crystals of snow, very often ground up by the strong wind. In wintertime large flakes of snow are very rare in the Arctic. In winter the air is oftentimes filled with icy needles, slowly settling to the surface of the earth. An important role in the growth of the snow cover in the Arctic is played by rime, which sometimes forms in large quantities. For example, on B. Lyakhov Island the growth of the snow cover in the fall and the beginning of the winter of 1929 proceeded in a uniform manner both as a result of the falling of precipitation (snow) and as a result of the "growing precipitation" (rime, hoar frost). The amount of "growing precipitation" is particularly great on the ice caps of the

Arctic islands.

A description of the Arctic winter necessarily involves the polar lights, which are observed most often in this season of the year. Cape Chelyuskin (having on an average 138 days a year with polar lights, 115 of these being in November -- March) it and B. Lyakhov Island (130 days in the year with polar lights) are the places in the Soviet Arctic where the occurrence of polar lights is the most frequent. During the year Novaya Zemlya, Franz Josef Land, and Dikson Island have an average of about 100 days with polar lights; Wrangel Island, about 90 days; Vaigach Island and the area of the Bering Strait, about 60.

Spring. March and April, belonging in the more southern regions to the spring months, have in the Arctic all the characteristics of winter. In March, over a great part of the Soviet Arctic, the mean temperature of the air is still below -20°; and in April it is below -15°. In the central part of the polar basin the minimum mean monthly temperatures are observed in the spring (in March -35°). In the extreme western part of the Soviet Arctic (Franz Josef Land, Novaya Zemlya, Vaigach Island), March is the coldest month of the year. The following list, giving the mean monthly temperatures of the air in Malye Karmakuly (on the basis of observations for 46 years), illustrates this characteristic of the yearly variation in temperature in the area of the Barents Sea:

I	II	III	IV	V	VI	VII	VIII	IX	X
-14.9	-14.8	-15.6	-10.9	-4.4	1.4	6.4	6.4	2.8	-2.8

XI	XII
-9.3	-13.3

The retardation in the Arctic of the yearly minimum of temperature of the air (in the case of the continental climate it occurs in January) is caused in the main by the giving off of heat by the sea. However, a certain role is also played here by the nature of the circulation of the air. For example, the relatively high temperature of the air in the western part of the Soviet Arctic in February is caused by the fact that here, during this time of the year, there are frequent intrusions of Atlantic air. In March they are much rarer, while the intrusions of cold Arctic masses of air become more frequent.

Picture (Page 47).

House of the polar station on Wrangel Island in the wintertime.

Even though the mean May temperature of the air in all of the Soviet Arctic (with the exception of the narrow zone of the Barents Sea adjacent to Murman Province) is lower than 0°, this month, as a rule, still has thaws. For example, in May, Malye Karmakuly had on an average for a number of years 7 days of thaw; Zhelaniya 3, B. Lyakhov Island 2, Tiksi Bay 10, Cape Cape/Schmidt 5, and Wrangel Island 3. Still, thaws in May on Franz Josef Land are very rare (on an average one thaw a month). During the time of the drift of the "Fram" in the Soviet sector of the polar basin, and also during the time of the drift of the "Mod" in the Eastern Siberian Sea there was no record of a single thaw in May.

While in the winter there is practically no daily variation in the tempera-

ture of the air in the Arctic, the daily variation is very distinct in the spring. In accordance with the observations of the Soviet polar stations and also the observations made during the time of the drift of vessels, the maximum yearly range of the daily variation in the temperature of the air occurs in April, when it reaches on an average 3 -- 4°.

In the Soviet Arctic the first half of the spring is a season when cloudiness is at a minimum and when clear days are particularly frequent. In the Soviet Arctic the probability of a clear sky in March is about 30%, and in April about 25%. In spite of the fact that March and April are the most favorable months from the standpoint of cloudiness, still, during this time of the year, the days with an overcast sky are more frequent than clear days. The probability of an overcast sky in the Soviet Arctic in March is about 55%, in April about 60%.

Even though ordinary storms and snowstorms still rage in the Arctic in the spring, they do not constitute, after the end of the polar night, such an obstacle to the activity of man as do the winter storms. With the bright light of the spring sun man does not feel so strongly the disagreeable features of the Arctic climate. Kh. Sverdrup, who passed six years in the Soviet Arctic writes: "Spring in the Arctic is marvellous. Colors are never so charming nor the snow cover so blinding white as in the spring."

Spring is the best season for dry land and air expeditions in the Arctic.

Summer. Since in summer the greater part of the land surface of the Arctic is covered with snow or ice (with the exception of the south sub-Arctic Zone), the temperature of the lowest layer of the air (at the meteorological stations the temperature of the air is generally measured 2 meters above the surface of the ground) cannot be very far from 0°. The most sensible deviations from this temperature are observed in the border zone of the Arctic.

Table 7 gives the mean monthly temperatures for the 3 summer months for a number of Arctic stations located in the order of decreasing geographical latitude.

1

As the observations of the drift stations "Severny Polius" and the "Fram" have shown, the temperature of the air in June and August in the central part of the polar basin is, on the average, below zero, and only in July does it reach the melting point of ice.

Table 7, page 49

Mean monthly temperatures

Stations	North Latitude	Mean temperature of the air		
		June	July	August
"Severny Polius"	88°50'-87°30'	-2°.5	0°.0	-1°.2
"Fram"	81 -84 40	-1 8	0 1	-1 8
Franz Josef Land	81	-1 0	1 4	0 4
Domashnii Island	79 50	-1 5	0 8	0 4
Cape Cholyushkin	77 43	-1 2	1 5	0 4
Cape Zhelaniya	76 57	-1 2	1 7	2 1
Dikson Island	73 30	0 0	4 6	5 2
B. Lyakhov Island	73 11	0 2	3 0	2 5
Malye Karmakuly	72 23	2 1	6 9	7 0
Tiksi Bay	71 39	3 2	9 2	8 0
Wrangel Island	70 58	0 5	2 4	1 8
Uellen	66 09	1 7	5 4	5 0

It is possible that the average temperature of the air in the part of the polar basin located between the north pole and the Bering Strait is below zero (by several tenths of a degree even in July.

The islands of the Soviet Arctic having the coldest summer are Franz Josef Land, Severnaya Zemlya (Domashnii Island) and Henrietta Island. Among those listed Tiksi Bay stands out by reason of its relatively warm summer, which is due to the influence of the continent. On Wrangel Island, located south of Tiksi Bay, but around which there is ice even in summer, the temperature of the air in the summer months is much lower.

Since in the broad expanses of the Arctic the basement rock surface has an almost constant temperature in summer (that is, the temperature of melting ice), the temperature of the layer of air closest to the earth's surface is characterized by its great constancy. The extremely small variations in the temperature of the air constitute one of the most characteristic features of the summer climate of the high Arctic. In order to give an idea of the summer temperature variations in the Arctic we have given in Table 8 the absolute minimum and maximum temperatures of the air recorded in July at different stations.

Table 8, page 50

Station	Minimum	Maximum
"Severny Polius"	-2°.0	2°.0
"Fram"	-3 4	3 6
"Mod"	-4 2	3 2
Tikhaya Bay	-2 8	9 9
Matochkin Shar	-4 0	17 5
Malye Karmakuly	-1 8	21 5
Dikson Island	-3 0	23 0
Wrangel Island	-4 9	18 2

As we can see from Table 8, the absolute range in the variations of temperature in July, in the central part of the polar basin, is very small. In the bordering parts of the Arctic the absolute minima in July are of the same order of magnitude as in the central part of the polar basin, whereas the maxima reach comparatively high values. This is explained by the fact that in the bordering parts of the Arctic the well-heated air brought from the continent either does not pass over the ice at all or if only for a relatively short distance and, hence, does not have time to cool off very much. Moreover, it is necessary to note that such high temperatures as the absolute maxima given above constitute rare exceptions even in the border zone.

The layer of strongly cooled air with a temperature close to zero, present

in summer over the polar ice, is relatively thin, and with an increase in altitude the temperature of the air increases. For example, in the last 10 days of June 1928, during the time of the ascent of the airplane of the "Malygin" expedition, which was stationed in a continuous ice field in the northwest part of the Barents Sea, the following temperatures of the air were recorded: at an altitude of 2 meters $-1^{\circ}.4$; 650 m $+3^{\circ}.0$; 1225 m $+5^{\circ}.8$. (no omission)

Such a vertical distribution of temperature is typical in summer for the bordering Arctic seas.

Along with a very constant temperature of the air close to zero, another highly characteristic feature of the Arctic summer is the great amount of cloudiness and the frequent fogs. In summer the probability of an overcast sky in the border seas of the Soviet Arctic is 65 to 85%, and the probability of a clear sky is only 10 — 15%. In June and August the amount of cloudiness is very great; in July, however, the conditions as regards cloudiness are somewhat more favorable (chiefly in the parts of the Arctic adjacent to the continent).

The amount of cloudiness in summer in the central part of the polar basin is exceptionally great. Thus, during the time of the three-year drift of the "Fram" not a single clear day was recorded in summer, whereas the number of overcast days during the three summer months amounted on an average to 77. The predominant form of summer clouds in the Arctic is the low stratus. During the time of the drift of the "Mod" in the East Siberian Sea/87% of the clouds were at a low level and only

covering the sky
15% were high altostratus clouds. The monotonous gray shroud of stratus clouds, day after day, gives to the Arctic summer a dismal character.

Nature is not adorned, and the thick fogs occurring very often in summertime are the worst enemy of navigation by sea and by air. The occurrence of this phenomenon is shown by Table 9.

Table 9, page 51

Number of days with fog

Points	June	July	August
Tikhaya Bay	12	15	16
Malye Karmakuly	8	11	10
Dikson Island	14	20	16
Cape Chelyshkin	14	24	25
B. Lyakov Island	15	17	16
Wrangel Island	15	17	16

A very large number of days with fog were observed during the time of the drift of the "Mod" in the East Siberian Sea: in June 20 days, in July 25, in August 26.

As shown by Table 10, it is possible to have snowfall in the Soviet Arctic throughout the summer.

Table 10, page 51

Number of days with snow

Points	June	July	August
Tikhaya Bay	8	7	7
Matochkin Shar	5	1	2
Dikson Island	8	4	4
Domashnii Island	6	5	7
B. Lyakhov Island	4	4	3
Wrangel Island	4	1	5
Polar Basin ("Fram")	17	14	14

In the high latitudes of the Arctic, solid precipitation is observed more often than liquid even in summer. The latter falls chiefly in the form of fine drizzly rain.

In the Arctic the average velocity of the wind reaches its yearly minimum in the summer. Storm activity (see Table 3) is also greatly weakened in this season of the year. However, in spite of the sharp decrease in the number of ordinary storms and the almost complete absence of snowstorms, the misty and damp summer is the most agreeable season in the Arctic.

In considering the climate of the Arctic, we cannot pass in silence the period of warming up, starting approximately in 1920 and continuing up to the present time. This warming up, particularly noticeable in the parts of the Arctic near the Atlantic, is the greatest variation of climate ever observed since the time of the invention of the thermometer. The mean seasonal temperatures of the air, given in Table 11 and computed for Malye Karmakuly and Franz Josef Land separately, on the basis of observations made before and after 1920, show in a very graphic manner how great the variation in climate has been.

Table 11, page 52

Time of the year	Malye Karmakuly 1920–1935	Malye Karmakuly 1876–1919	Malye Karmakuly Difference	Franz Josef Land 1920–1936	Franz Josef Land 1873–1914	Difference
Fall	-7°.1	-9°.7	2°.6	-8°.5	-13°.5	5°.0
Winter	-11 9	-15 9	4 0	-18 3	-25 4	7 1
Spring	-10 3	-10 3	0 0	-15 7	-17 4	1 7
Summer	5 5	4 7	0 8	0 3	0 1	0 2

As we can see from Table 11, the warming up showed itself chiefly in the fall and winter, whereas the change in the temperature of summer and spring has been much less. It is interesting to note that after the warming up of the Arctic the mean fall temperature on Franz Josef Land was higher than on the south island of Novaya Zemlya (Malye Karmakuly) before the period of increasing warmth.

The cause of the warming up of the Arctic is the general intensification

in the circulation of the air, as a result of which large quantities of warm air began to move into the Arctic from the ocean. Together with the intensification in the general circulation of the air, there has also been observed a change in the activity of cyclones, which in the Arctic began to move along high latitude trajectories (north of the 80th parallel) much more often than before 1920.

GEOLOGICAL STRUCTURE

While the island groups of the Soviet Arctic differ sharply from each other in geological structure, they at the same time show a considerable resemblance to the parts of the continent adjacent to them. We shall give a more detailed geological description of the structure of the islands in our consideration of each separate group; here, however, we shall dwell only on the structural characteristics of the islands of the Soviet Arctic and the north littoral of Eurasia as a whole.

The western part of the Soviet Arctic is located in the area of the East European or Russian platform, on which all the rocks, beginning with the lower Paleozoic, were not subjected to any considerable disturbance by folding. In the opinion of A. D. Arkhangelsky, this platform continues towards the north up to the latitude of Spitsbergen and Franz Josef Land. This opinion is confirmed by the fact that even the Lower Paleozoic deposits in the eastern part of Severnaya (Vostochnaya) Zemlya lie horizontally and consequently that no ancient Paleozoic (Caledonian) folding took place here.

To the east of the territory considered, the basic structural element is the zone of the Upper Paleozoic (Hercynian) folding, which includes the Urals, the Pay-Khoy system, Vaigach, and Novaya Zemlya, and also Taimyr and Severnaya Zemlya. The structure of the aforementioned zone of folding, as outlined in accordance with the most recent data, is rather complicated. The meridional folds of the Urals at their northern extremity turn toward the northeast. The folds of Pay-Khoy, with a northwest direction, come close up to them, and continue on toward Vaigach and the south island of Novaya Zemlya, where they turn sharply to the

northeast. The folds of Taimyr run in a direction that is almost latitudinal, changing in the eastern part of the peninsula to a northeast direction. In Severnaya Zemlya, however, the general direction of the folds is meridional. Apparently, the Upper Paleozoic folding zone does not reach far to the east, a proof of which is the Paleozoic of the New Siberian Archipelago, which has not been displaced to any extent and is probably a part of the periphery of the folded area. However, as yet we do not know the character of the termination of the Hercynian folded zone to the north and to the east of Severnaya Zemlya; and we do not know whether it stops here or extends on into the central part of the polar basin.

In the western part of the Soviet Arctic we must also note the appearance of the Mesozoic folding, expressing itself only in the formation of sloping folds, which have generally followed the direction of the folds of the Paleozoic basement rock. We find such folds in the Pechora lowlands, on Franz Josef Land, in the western Siberian lowlands, on the islands of the Kara Sea and, finally, in the Taimyr depression, which limits on the south the Taimyr folded area and which is a part of the Siberian platform, which separates the above-described Upper Paleozoic folding zone and the Mesozoic folded structures of northeast Asia.

In the northeast part of the USSR the Mesozoic zone of folding includes almost all of the territory to the east of the Lena, and also the south part of the New Siberian archipelago and Wrangel Island. The direction of the folds in the limits of this zone of folding is determined first of all by the presence in its central part, in the basins of the Kolyma and Indigirka, of a more stable middle mass and, second, by the presence of a rigid resistance to the north of the folded area (according to the assumption of A. D. Arkhangelsk, in the central part of the polar basin). As yet we know nothing concerning the nature of the latter. The Tertiary folds in the limits of the Mesozoic folding zone in the northeast evidently developed just as did the Mesozoic folding in the western part of the Soviet Arctic, that is, in the form of sloping folds

following the direction of the more ancient structure. We have such folds in the New Siberian Islands and in the littoral regions of the continent between the Lena and the Indigirka.

The isolation of many islands, their present outline, the direction of the straits separating these islands, and even the distribution of the elevations on the islands were all, evidently, caused to a large extent by the fractures taking place in the Tertiary or Quaternary periods and by the rising and sinking of separate sectors of the earth's crust.

There is no doubt that there is a connection between the seismic disturbances observed at the present time in the polar areas and these latest stages of geological history of the Soviet Arctic. As a rule the number of earthquakes in the Arctic is small. For example, during the 7 years (1918 -- 1924) only 20 heavy earthquakes were recorded in the limits of the Arctic Zone, whereas during this same time 100 earthquakes were recorded in the south part of Eurasia, earthquakes which were detected by stations 80° away from the foci. In the Arctic there is a seismic belt running from Iceland along the eastern shore of Greenland to Spitsbergen, Franz Josef Land and farther on through the central polar basin to the mouth of the Lena River. A number of island groups of the Soviet Arctic (Franz Josef Land, Severnaya Zemlya, the New Siberian Islands), the outlines of which are determined to a great extent by young fractures, gravitate towards this belt.

The extensive geological work carried out in the Soviet Union, particularly in the Far North, has made it possible to establish the basic facts pertaining to the geology and the mineral deposits of the islands of the Soviet Arctic, almost unknown before.

For the discovery of all the wealth concealed in the sub-soil of these islands we must have additional investigation. We must bear in mind that the exploitation of the natural resources of the islands of the polar basin may be profitable in view of their proximity to the North Sea route. Among the resources of industrial importance we can mention at the present time only the lead-zinc

and copper deposits on Vaigach Island. It is easily possible that we may discover such deposits in Novaya Zemlya, which is a continuation of the island of Vaigach.

In the Kirov group of islands in the Kara Sea and on Severnaya Zemlya (Komsomolets Island) there are outcrops of coal seams which may be suitable for working. The known deposits of brown coal on Franz Josef Land can scarcely have any great practical importance because the archipelago is so far away. Severnaya Zemlya, the New Siberian Islands and Wrangel Island have not yet been studied sufficiently from a geological or prospecting standpoint.

Among the processes developing in the Quaternary epoch and leaving very distinct marks upon the morphology of the polar regions, glaciation certainly occupies the chief place.

There is a great amount of proof in the form of the remains of moraines, fossil ice and ice forms of relief, indicating a very extensive development of Quaternary glaciation in the limits of the Arctic.

In the epoch of the maximum glaciation, Novaya Zemlya, Vaigach, and Severnaya Zemlya disappeared under a continuous ice sheet extending far to the south, onto the continent, where the ice occupied all of northern Europe and the north part of western and central Siberia. The shore line at that time was much farther north, and all the islands of the polar basin, with the exception, perhaps, of Franz Josef Land and Spitsbergen, formed a part of the European continent.

On the New Siberian Islands, Wrangel, and on the north littoral of Yakutia (Yakutsk) the deposits of maximum glaciation have still not been classified in an accurate manner. After this glacial epoch the sea inundated the north part of the continent, the inundation being most extensive in the western part of the area considered.

Later, there was a second less extensive glaciation. On the islands of the eastern sector of the Soviet Arctic it expressed itself only in the formation of a slow-moving or almost stationary firn field conserving itself in the form of fossil ice up to the present day. The epoch after the second glaciation

Picture, p. 56. Novaya Zemlya. Western part of Matochkin Shar}

marked the second limited transgression.

On the New Siberian Islands, on Wrangel Island, and on the littoral region of the continent adjacent to them the aforementioned epoch was a time when animal and plant life flourished, when mammoths, rhinoceroses, bison, wild horses, and reindeer roamed over the expanses covered at the present time by tundra, and when the forest vegetation reached up to 74 - 75 degrees N. latitude. The cooling-off period following after this caused, in the eastern part of the Soviet Arctic, a recession of the forests and, probably, the destruction of the majority of the animals of Quaternary time. This cooling off led to the advance of the glaciers of Novaya Zemlya, Franz Josef Land, and Severnaya Zemlya and coincided in time with the recession of the sea.

At the present time glaciers are by no means to be found everywhere on the islands of the Soviet Arctic. While Franz Josef Land is almost entirely covered with ice, and half of the north island of Novaya Zemlya is covered with ice-bergs, more than half the area of all the islands of Severnaya Zemlya, which is in a higher latitude than Novaya Zemlya, is free of the ice sheet. There is no glaciation of the present time on the New Siberian Islands; the only glaciers are the small ones in the De Long group of islands. Finally, still farther to

Picture, p. 57. Khaptashinsky Yar. Fossil ice.

the east, on Wrangel Island, there are scarcely any glaciers. Hence, we note a distinct subsidence of glaciation from the west towards the east, a condition which may, no doubt, be attributed directly to the change in climatic conditions and in this direction first of all to the decrease in the quantity of precipitation. At the present time, wherever there are glaciers on any of the islands of the Soviet Arctic, we may observe clear signs of their recession.

Ever since the beginning of the Ice Age there has been eternally frozen ground on all the Arctic islands, a condition which has left its impression upon the relief, in the course of the processes of weathering, the character of the hydrographic network, and the vegetation.

Up until a short time ago we knew very little concerning the eternally frozen ground and its thickness; and it is only during the last few years, in connection with the development of geological-prospecting and mining work in the Far North that we have gathered a great amount of factual materials pertaining to eternally frozen ground. On the north littoral of Siberia, the thickness of the eternally frozen layer is very great in places: at Anderma on the Yugorski Peninsula it is not less than 400 meters; in Nordvik, close to the mouth of the Khatanga River, it is 600 meters; and on Vaigach Island it is not less than 400 -- 500 meters, while this eternally frozen ground does not extend beyond the

limits of this island to the bottom of the Barents Sea. Eternally frozen ground may exist even at the bottom of those northern seas which have been formed by the sinking of dry land embraced by eternally frozen ground and where warm currents do not reach the bottom.

Such a condition has been discovered, for example, in the Dm. Laptev Strait between the New Siberian Islands and the continent. At the bottom of this strait there has been discovered a layer of ice that has not melted because the layers of sea water near the bottom have temperatures below zero.

However, if the rock making up the sea bottom is saturated with sea water having a high percentage of mineral salts, firm eternally frozen soil should be absent even at the bottom of cold seas, because salt water may be in the liquid form at temperatures as low as -5 degrees Centigrade. Such underground water may be a serious hindrance to mining operations. It shows clear signs of maring a origin and occurs most often in the coastal zone. The temperatures of the soil in the zone of eternally frozen ground drop in B. Nordvik down to -12 degrees; at Amderma and on Vaigach Island the drop does not go below -5 degrees.

The presence of eternally frozen ground exerts a tremendous influence upon the processes of soil formation and weathering of rock. The existence, at depths of some tens of centimeters from the surface, of eternally frozen ground, impenetrable for water, leads to the permanent supersaturation of the active layer (because of the gradual melting of the eternally frozen ground below). This circumstance determines to an extensive degree the dynamics of Arctic soils. The influence of eternally frozen ground shows its effects upon the microrelief of the surface, on the formation of the so-called "polygonal" and "structural soils," which form under the action of the movement of the water and the partially liquefied rock in the active layer when it freezes and thaws. The prevalence of a given type of microrelief will depend upon the condition of the groundmass. On the stony fine earth soils we have "structural" soils, characterized by the sorting of heterogeneous soil materials ("stone rings," stone nets, stony strips, "earth" islands); on the clayey soils we have "polygonal" formations, consisting

of homogeneous fine materials, broken up into separate polygons. As elements of microrelief connected with frozen soil we must also mention the forms of spotty and mound-like tundra, characterizing the more southern zone of the sub-Arctic tundras, extending only to a very few of the islands of the Soviet Arctic (Kolguev Island, part of Vaigach Island).

Owing to the fact that the longest season of the year is winter and also owing to the presence of frozen soil, weathering in the Arctic areas is limited in the main to physical processes and first of all to the processes of frost weathering. There is also chemical weathering, but the part it plays here is small in comparison with what it is in the more southern latitudes. A particularly important factor in the zone of eternally frozen soil is the action of the sun's rays (insolation), which tends to give a different character to slopes having different exposures. With the melting of the active layer on slopes made up of crumbly rocks (clay or dust-like soil) there is a flow of the soil (solifluction) resulting in a wearing down of the slopes. One cannot fail to note the erosive action on slopes of the snow in places that are protected from the sun throughout the summer. In the "intermediate mountain" areas, the work of snow, jointly with the processes of solifluction, causes the appearance of peculiar terrace-like steps on the slopes of the mountain, known as mountain terraces.

River erosion, in the presence of eternally frozen ground and the short summer, is retarded, while as a result of the sharp variations in the level of the river lateral erosion prevails over erosion in depth. This leads to the formation of wide valleys with flat bottoms, many times taking on a trough-like form. Frozen soil also contributes to the development and conservation of lakes (extremely numerous in all level areas), formed by the melting of the lenses of ice buried in the ground, causing at times the development of the so-called "thermokarst" physiographic provinces (the New Siberian Islands).

The relief of the littoral areas and the islands of the Arctic, developing under rigorous climatic conditions with the combined action of glaciers and breakers from the sea, with erosion taking place in the presence of eternally

frozen soil and the flow of supersaturated soils (solifluction), is characterized on the whole by rather smooth forms of elevations and by an extensive development of littoral alluvial plains.

We give below the characteristics of the relief of the separate groups of islands.

SOILS

The soils in the Arctic do not form a continuous cover, because the conditions making soil formation possible are not present everywhere by any means. Considerable areas, occupied by ice or eternal snow, from which rise naked crags, have no alluvium and, hence, no soil. The energetic processes of frost weathering lead to the breaking of the rock, and the products of weathering are carried away by temporary streams and winds to the littoral area, forming the wide coastal terraces. The accumulation of friable products also takes place in the valleys of rivers and in the depressions of the relief. For a great part of the year these friable deposits are in a frozen condition, and it is only for a very brief period during the short summer that the upper layer melts, and even then it melts only to a depth of 20 to 40 cm. The eternally frozen ground lying deeper forms a water-resistant horizon, owing to which the layer that melts becomes supersaturated and viscous-like. The repeated freezing and thawing of the ground produces complicated displacements of the separate component parts of the ground (solifluction), as a result of which there takes place an interminglings of the soils (soils in a geological sense) and sliding along the slopes. The moving and shifting of the soil is not favorable for soil formation processes, which are possible only on separate limited areas, made up chiefly of soil containing less water (from sand to loam).

An unfavorable influence on soil formation processes is also exercised by the almost complete absence in the soil of organic substances, because the vegetation of the Arctic is very poor and does not form a continuous cover, and,

in addition to this, at low temperatures there is scarcely any decomposition of organic substances. In cold soils all biological and chemical processes take place very slowly, and, hence, the soil has an undeveloped or rudimentary character.

The process of soil formation, depending upon the climatic and rock conditions, develops either in the direction of the initial stage of podzol formation or in the direction of the gley-marshy type. In places that are well warmed and drained (usually on sands) and on islands with a milder climate, we may find cryptopodzol or weak podzol soils, but, in places with more moisture and where the moisture, absorbed by the soil, prevents the access of oxygen there is a process of restoration, and gley-marshy soils are formed. Almost the whole thickness of the greater part of cryptopodzol soils is also gley in structure. On the surface of the soil at the bottom of closed depressions, filled in the spring and dried out in summer, we sometimes find efflorescences or even thin crusts of easily-dissolved salts, disappearing when it rains and reappearing when it is dry. These salt soils are found only in places where the component rock contains readily soluble salts and where there is not even a temporary flow of water.

Picture, p. 61. Polar poppy.

VEGETATION

The greater part of the islands of the Arctic Ocean belong to the zone of polar deserts. Only some of the more southerly islands of the west sector of the Arctic, as, for example, Kolguev and Vaigach, are in the tundra zone.

The scant vegetation of the polar deserts of the dry land of the Soviet Arctic provide food for only a small amount of animal population. The basis of the existence of the mass of marine animals, birds, and fish constituting the industrial wealth of the Arctic consists of the vegetation of the sea, made up of free-moving microscopic alga of the surface layers of the sea water, namely, plankton, and of the larger, and sometimes very large thallus alga, the so-called benthos, which clings to the sea bottom.

Only a short time ago the prevailing opinion, expressed first by Nansen, was that plant and animal life were fairly well developed only in the parts of the Arctic Ocean close to the continent and that in the waters permanently covered with thick pack ice, around the poles, there was practically mmr no vegetation. However, the investigations of Soviet scientists (Shirshov) have shown the incorrectness of this view. In reality, the light penetrating through the ice from which the snow has melted proves to be sufficient for the development, in August, of a rather abundant plant plankton of Arctic diatomic alga (Chaetoceros socialis and others) to a depth of 5 - 20 meters. This plant plankton serves as food for the zooplankton, consisting chiefly of other larger animals, even close to the Pole.

In the bordering seas of the Arctic Ocean, covered in the summer only with broken ice, it is not rare that over large areas free of ice the more favorable conditions of existence make possible a comparatively long and abundant development of plant plankton, represented in the main by diatomic alga in the spring (Thalassiosira gravida T. Nordenskjoldi, Fragilaria islandica) and the peridinians (Chaetoceros and others) in the summer. The mass development ("flowering") of phytoplankton coincides with the beginning of the thawing of the ice and

continues for 15 - 20 days, and after this the quantity and composition of the plankton changes, because the seaweed, having used up the food salts of the surface layers of water, begins to die. This process is accelerated by the devouring of the alga by the animals. Under the winter cover of ice, the growth of plant life is stopped until spring.

In the south of the Barents Sea, the waters of which are affected to a considerable extent by the action of the warm saline current of the Atlantic, the plankton is poorer in Arctic Ocean forms; the latter begins to prevail in the northern half of the sea, the part subjected to the influence of the cold currents from the east.

The plant life of the polar marine basins is not limited to the upper layers of water but is found even on the floating ice. Certain microscopic diatoms (Melosira hyperborea), normally living in the surface layer itself, freshened by the melting of the ice, many times form a brown-colored deposit on the buried parts of the ice blocks. A still greater quantity of slimy accumulations of diatoms is found on the bottom of the numerous pools of fesh water formed in summer on the ice fields. The brown oozy colums of diatomic alga, developing rapidly in the sunlight, absorb the warmth and make possible a deepening of the small depression in which they live. The ice, perforated by holes and filled with cavities, becomes my weak and easy to break by the end of the summer. Diatomic forms often accumulate even in melting snow, giving to it a greenish-brown tinge.

Beds of large alga are met with in the littoral waters of the Arctic Ocean almost up to 80° N. latitude. The local natural conditions exercise an influence upon their distribution: extensive and thick fields of alga are particularly characteristic of shore stretches with a stony bottom where the alga can attach itself firmly; on the contrary, seas with a slimy or sandy bottom are poor in alga.

The development of seaweed (alga) is also favored by the higher temperature of the water, its transparency and saltiness; in the very cold muddy and fresh

water there is little seaweed. Strong breakers and storms also exert a harmful influence, while the effect of floating ice, which scrapes the bottom, is particularly harmful. In many places the floating ice makes the zone of high tide and the upper so-called littoral zone of the polar seas unfit for alga. In the deeper sub-littoral zone, other conditions being favorable, we may even have beds of brown and red seaweed (Laminaria digitata, L. sacharina -- phyllofores, polysiphons, phyllaria, fucus -- Fucus inflatus, F. serratus and others), while the smaller green algae are more characteristic of the littoral regions. Certain species of Laminaria and phyllaria reach great lengths (up to 2 - 4 meters). Generally, the large algae constitute a typical resource of the Arctic seas. Below 20 meters the brown algae almost disappear and only the red remain. Of these the calcareous "lytotamnious" and "phimatolitons," reminding us of corals, reach a depth of 50 - 80 meters, forming there a crust on the surface of the stony bottom.

The Barents Sea is the richest in algae. Their development here is favored in particular by the transparent, salt , and comparatively warm water coming in from the Atlantic. Large fields of alga are found here along the stony banks of the Murman littoral and Novaya Zemlya. On the contrary, in the seas of the Siberian continental platform there is little alga and it does not grow so luxuriantly here because the bottom, owing to the shallowness, ~~mk~~ * is mostly slimy or sandy, and the waters themselves of the Siberian seas, especially the Kara Sea, are freshened and muddied by the waters of gigantic rivers.

Abundant beds of large algae again appear in the Chuckchee Sea, with its stony littoral areas. In the seas of the Arctic Ocean the total number of species of green, brown, and red algae reaches 150.

While in the waters of the Arctic the conditions for the existence of plants are sufficiently favorable, the same is not true for the dry land. Here they are very unfavorable. The short and cold growing season, strong winds, and thin and compact snow cover make impossible not only the growth of trees but also of shrubs. It is only on Kolguev Island and here and there on Vaigach Island that

we may find shrub beds of polar ivy and dwarf birch. On the other islands, however, the vegetation scarcely rises above the surface of the ground; and even this scant vegetation is made possible by the warmth of the layer of air next to the ground in summer and the protection offered by the stones and hillocks from the driving snow and sandy winds in winter. The strong winds have a most destructive effect upon the vegetation, because they not only dry up the plants and mutilate them, but they also denude the soil of the protective layer of snow on open places or, on the contrary, form on the lee slopes and in the depressions a thick snowdrift which occasionally does not have time to thaw before the following winter.

The extremely varied regimen of the snow cover is one of the contributing causes of the lack of uniformity in the development of plant life; hence, throughout the growing period, certain species of plants are found in the most varied stages of development.

In the wintertime, at places without snow, plants even bear seeds (fruit), while on the edges of the melting snow fields they are just starting to grow. A considerable part of the vegetation disappears under the snow, without even completing the flowering period, and passes the winter in a green condition. This circumstance has great importance for the herbivorous animal population of the Arctic, because it receives in the winter what we may call a natural forage, conserving its food substance, and not just dry straw withering while standing.

The severe natural conditions of the Arctic, first of all the short growing season, still amounting to almost 3 months (Zubkov) in the warmer surface layer even on the north island of Novaya Zemlya, do not contribute to a varied flora. Only a few plants are able to get along with the small amount of heat and the cold soil, melting to a depth of only a few dozen centimeters; a few plants are able to survive the snowstorms, which frequently occur even in summer, and to withstand the strong winds and develop normally with continuous illumination throughout the growing season.

The flora of the Arctic is very poor. For example, on Franz Josef Land

there are only 36 known species of cryptogamous (flowering) plants, 94 lichens, and 82 species of moss. In Novaya Zemlya, lying to the south, the flora is richer: here there are 208 known species of cryptogamous plants, about 450 lichens and about 150 mosses. The scanty flora of Novaya Zemlya and the New Siberian Islands has been investigated very little; up to now we have found only about 10 flowering plants on Novaya Zemlya. The flora of Wrangel Island is richer, having about 160 flowering plants and approximately the same number of lichens and mosses.

The vegetation, in adapting itself to the natural conditions of the Arctic, in question has taken on a characteristic appearance. If the plants/are of the ligneous type (shrubs, such as the polar willow), their stems are very close to the soil, many times buried in the soil and the inflorescences rise above the surface of the ground only about 2 — 5 centimeters. If the plants belong to the family of grasses, which, by the way, are the prevailing forms among the flowering plants of the polar deserts, in contrast to the tundra, where shrub forms prevail, they generally form a thick cushion, which resists the cold, deflocation, and snow abrasion of winter. The flowers of the Arctic plants seem especially bright and large in contrast with the small grass forms which lie close to the ground. The majority of the Arctic plants belong to the perennial type; it is only in the more southerly parts of the Arctic that the annual types begin to appear, for example, the Boenigia islandica and the marshy tagpool (ranunculus confertus).

As we have already recalled, many of the flowering plants of the Arctic go through the winter in a green form, many times with incipient flowers. Such, for example, is the cochlearia groenlandica, which protects explorers and permanent inhabitants of the Arctic from scurvy. The ability to pass the winter in the bud state is possible for the plants of the Arctic to develop ripe seeds during the short growing period, but many of them have developed vegetative reproduction by means of bulbs and runners. So-called asexual reproduction of plants (multiplication by means of bulbs) is rather common in the Arctic. As an example we may mention the drooping saxifrage, the clustered saxifrage, the

of various meadow-grasses
sexually-reproducing knot weeds, sexually reproducing forms/(Roa alpigena, P. arctica). Certain plants of the Arctic, being representatives of a more southerly boreal flora, do not produce fruits (seeds) at all; they reproduce only by the vegetative method (the cloudberry, the bog bilberry, the red bilberry, dwarf birch). These plants indicate that even a relatively short time ago the Arctic had a more moderate climate. During this period the forest zone, with its coniferous forests, mossy marshes, and forested tundra, occupied the present-day tundra areas and the tundra extended to the north polar deserts.

In addition to the poverty of their flora and their peculiar forms of life, in what way do the polar deserts still differ from the tundra? The most typical peculiarity of the polar deserts of the Arctic is their thin cover of vegetation. The vegetation, consisting of mosses, lichens, and grass, flowering plants and in places also of colonies of alga, does not form a continuous cover, but consists of torn tufts of sod or even of separate plants scattered on the naked clay and stony soil. A peculiarity in the development of plants (observed by Darwin) on the limits of their existence is sharply expressed in the Arctic; here, plants must carry on a struggle not only with each other but also with the elements.

The extremely difficult conditions for plant life are constituted by the gravelly soil and the stony deposits from mountainous peaks, appearing only recently from under the icebergs and the firn fields and also the snowy spaces themselves. On the nunataks of Novaya Zemlya, with the exception of tufts of moss and thin layers of lichens, there grow only separate compact cushions of polar poppies with yellow flowers and saxifrage (Saxifraga oppositifolia) with dark rosy flowers. In the upper layer of the melting Arctic snows colonies of microscopic algae (Sphaerella nivalis), giving the snow a rosy color, are very widespread.

The steep slopes of the mountains, close to the seashore and free from ice and snow, have a somewhat richer and more varied vegetation. On Franz Josef Land there basalt crags and rock waste are abundantly watered by the ice melting above. At places where springs come out and near the streams of snow water,

enlivened here and there by green ~~grass~~ strands of algae, there are bright green, dark rose-colored, and greenish-yellow cushions of moss, from which rise the yellow flowers of the snow crowfoot and the white inflorescences of spoonwort and a few others. Higher up along the slopes, especially where the steep crags begin, even this hardy vegetation disappears. There remain only a few green compact sod-like masses and accumulations of surface seaweed. Along the dry lower partsoof the slopes and on the shore terraces we may find quite an abundance of such typical Arctic plants, never forming a compact cushion, as the dark rosy and white Saxifraga oppositifolia, S. caespitosa, yellow whitlow grass, white Alsine, yellow polar poppy, certain grasses (Alopecurus alpinus, Poa alpigena). The hemispherically-shaped flowers and mosses reach 30 cm in diameter and from a distance remind us of "colored stones." In places the variegation of the stony-clay surfaces expanses of the littoral is reinforced by shrubs and crustaceous lichens, the white, yellow, orange, and grey spots of which compete in brilliance with the flowers.

Such scanty vegetation is characteristic of the western sector of the Soviet Arctic, the northern islands of which are still, so to speak, in the glacial epoch. The islands to the east of Taimyr constitute an entirely different physiographic province. Only the mountains of the small islands of Henrietta and Jeannette are covered with icy domes; on the mountains of the New Siberian Islands and Wrangel Island, however, glaciers are either absent entirely or insignificant; hence, the vegetation of the stony deposits covering the slopes of the mountains and their peaks are more ancient and richer. On Wrangel Island we may distinguish zones which probably exist also in the other parts of the Soviet Arctic where there are no glaciers. At elevations of 700 meters above sea level flowering vegetation is absent, but in the deep stony deposits there are quite a few lichens, such as the crustaceous and the bushy types; there are very few mosses. At lower altitudes, up to 150 meters above sea level, there is also a prevalence of stone alluvial deposits with poor vegetation consisting of lichens and mosses, but on the terraces and flat tops with accumulations of fine earth we find the

so-called polygonal deserts. Their vegetation closely resembles the vegetation of the polygonal deserts of the lower areas but is somewhat poorer.

Picture, p. 68. Forget-me-nots.

Picture, p. 69.

Lichen-moss polygonal desert on the New Siberian Islands.

Even the ridges and rocks standing out along the edges of the icy sheets of the islands of the western Arctic and the deposits of dark schist along the

slopes of the mountains on the islands of the eastern Arctic seem to be without life because of the poverty of the vegetation and the insignificant amount of animal life. In contrast with these, the low stony terraces of the littoral produce a special impression upon the traveler in the summer, with their bright spots of flowers and numerous large bird colonies. Among the areas of gravel-slay, broken up into irregular polygons by a network of channels caused by frost cracks or stony strips, the vegetation is rather noticeable on the landscape. On the basis of the prevailing types of vegetation and the degree of their development we may distinguish the lichen moss and the grass polar deserts.

The most dismal impression is produced by the latter, which is distributed over the flat young clay plains of the Uedinenia, New Siberian and Wrangel Islands. The moist sticky soil reminds us very much of a freshly-plowed field in the spring, on which, among the clods of crumbling earth, there are still some bunches of grasses (Alopecurus alpinus, Deschamsia brevifolia), Lusula nivalis, sod mosses and lichens. In the low places there are numerous bright lakes and pools. They do not dry up easily because of the shallow water-resistant layer of eternally frozen ground, thawing by the end of the summer to a depth of only 30 --- 50 cm. The littoral of these shallow reservoirs of water become green with a denser vegetation, consisting chiefly of mosses and grasses. The latter serve as food for the many geese and snout beetles flying here in the summer. Thousands of birds eat the grass, sometimes level with the ground, and fertilize with excrement the soil-soaked water.

The high hilly plains, and especially the low, flat mountains, attract attention by reason of their lichen and mossy polar deserts. The first occupy the dryest and stoniest sector; and the second occupy the damp shallow soil sectors. A system of strips and spots of vegetation occurring in connection with the frost fissures, which break up the surface into irregular polygons, is typical both of the lichen deserts and the mossy polygonal deserts. Stones accumulate in the stony substrata, in the troughs of the frost fissures and protrude from the moist soil as it freezes and melts.

A great part is played in the vegetation of the lichen polygonal deserts

by the white Thamnolia vermicularis, which forms a contrast with the dark brown, almost black, tangled felt-like Bryopogon divergens. The bushy reindeer moss, Cetraria, and Alectoria are also very abundant in places.

In the troughs along the slopes of the river valleys, protected from the wind, and on the low mountains we may find an almost genuine lichen tundra with a continuous moss-lichen cover and a rather rich grass and bush zone.

The moss polygonal deserts are more widespread on the level clayey spaces. Many times they have a very original appearance, due to the alternation in their reddish purple sod-like cushion of Arctic moss (Grimmia gracilis) and the green cushions of other mosses (Oncophorus Wahlenbergii, Aulacomnium turgidum, Drepanocladus uncinatus).

There are also lichens (especially Thamnolia) and flowering plants. Among the latter the grasses (Alopecurus alpinus, Deschampsia brevifolia) predominate, but we may also find other flowering plants, such as the Alsines, the saxifrages (Saxifraga conosa, S. cassnitosa), crowfoot, Lusula nivalis. Certain polar willows (Salix polaris, S. pulchra), almost completely buried in the moss layer, also find shelter here.

The naked soil spots between the strips of vegetation, occupying from 25 to 50% of the surface, are due in the main to the strong winter winds, which, with the snow, polish all the elevated places, more rarely to the spring floods, which easily destroy the weak sod, and also the flow of the thin supersaturated soil layer along the slopes. In protected places, where in winter there is a sufficient snow cover and where the spring floods are not strong, we may always find sectors of continuous vegetation covering larger areas. Under these conditions we many times have wet moss marshes with sedge and marsh grass. With their green freshness they enliven the half-naked terraces and slopes of the islands of the eastern sector of the Arctic and the more southern islands, free of glaciers, to the west of Taimyr.

Particularly large areas of moss-clad marsh exist on the south island of Novaya Zemlya, where they are even Sphagnum bogs.

Morasses with continuous vegetation may exist only in those places which in summer have an abundance of moisture and in winter a sufficient snow cover. However, this snow cover should not exceed a certain depth; otherwise it does not have time to melt in summer and then the vegetation suffers. In the Arctic the snow cover is capable of helping the plants only when it is not excessive. This is clearly noticeable in the case of vegetation on the slopes of hills and mountains, where the winds pile up thick drifts of snow, melting slowly in summer. Here we find a very thin and ragged plant cover, easily distinguished from the plant cover of the polygonal deserts not only by its composition but also by the fact that it does not form a regular network. The very short growing season and the washing of the ground by flowing water are such that the soil is capable of sustaining only a few plants. On the soils soaked with water there are scattered cushions of green moss (Dicranowei sia crespula) and brown lichens (Cetraria Delisei), and the prominent flowering forms are the small sod types of whitlow-wort with yellow and white flowers (Draba alpina, D. lactaea, D. herta) and Arctic dock or sorrel (Oxyria digyna), yellow crowfoot (Ranunculus pygmalus) and many others.

At the end of the summer, when the slopes of the mountains and hills are almost completely free of snow fields, the places where the snow was form dark spots, occupying at times a large space. The light green grass and mosses are lost among the sectors of naked land and the sod of brown lichens.

The plant cover of the Arctic becomes richer and denser towards the south. Even Vaigach and Kilguev Islands, bathed by the comparatively warm waters of the Barents Sea, cannot be counted in the zone of the polar desert. The latter is recalled only by the separate sectors of polygonal deserts and the spotty tundra, existing on the areas open to wind and snowstorms, on the gravelly lichen tundra, and on the stony elevations. Over the rest of the space the prevailing forms are tundra with a continuous lichen and moss cover and moss marshes; on Kolguev Island, on the protected slopes and in the valleys of the small rivers, we also encounter shrubs of polar willow and dwarf birch up to 50 cm in height. The

moderate climate and the abundance of plant food make it possible for the reindeer industry to thrive here without difficulty. Here and there it is even possible to grow certain hardy vegetables in open ground, whereas in the zone of the polar deserts agriculture can be carried on only in greenhouses.

ANIMAL LIFE OF THE SEAS AND ISLANDS

The animal life of the seas and islands of the Soviet Arctic is rather rich and varied, in spite of a widely prevailing opinion to the contrary. For example, we have already counted several thousand species. Not only the sea is inhabited, from its bottom to its surface, but every sector of dry land not covered by a glacier, however small it may be, even including the separate nunataks projecting from the ice. In origin, composition, and distribution this fauna is extremely varied. A part of it, made up of certain rather large groups of animals, represents the remains of the ancient preglacial fauna of the Arctic, which at that time had a milder climate. The other part penetrated into the Arctic from southern regions during interglacial and chiefly post-glacial times. This moving into the Arctic of southern elements is still continuing even at the present time. The formation of present-day Arctic fauna took place in the sea and on the dry land by different routes. Hence, it will be more convenient to consider the land fauna and the marine fauna separately.

The animal life of the islands of the Soviet Arctic, in the parts of it which represent the remains of the ancient fauna of the given territory, was subjected to repeated periods of glaciation during Quaternary time, to transgressions and recessions of the sea, and changes in the relief of the dry land, producing as a result two Arctic faunas: a European and an East Siberian. On the continent there was formed still a third, namely, a West Siberian fauna, which has not yet been discovered, however, on the Arctic islands. The dividing line between the two aforementioned faunas runs, for the islands, in the area of the New Siberian archipelago, where there has been found a mixing of western

and eastern forms. But on Severnaya Zemlya and the islands of the Kara Sea we we find only western forms, both in the case of sea animals and land animals.

Of the islands of the Soviet Arctic we have more or less satisfactory (but far from complete) information concerning the fauna as a whole of the following: Novaya Zemlya (and only in part for Vaigach), for certain of the New Siberian Islands and for Wrangel Island.(1)

(1) As representatives of the European section of the Arctic we may cite the following ancient species forming a part of the fauna of Novaya Zemlya: butterfly-cutworm moth (Agrosiphila lyngeâ, butterfly-snout moth Titaniodes moltschanovi Kusnezov sp. n., beetle or coleoptera Homalium polare, ground beetle Boreobia imitatrix) Similar representatives of the east Siberian section of the Arctic are the following for the New Siberian Islands and Wrangel Island: the butterfly (Paraschoeyenia birulai Kusnezov n. gen., sp., butterfly Oeneis semidea and Erebia fasciata. We may also mention several ancient forms characteristic both of the eastern and the western islands of the Arctic, as for example; the bug Calacanthia trybomi, "long-legged mosquito" Tipula convexifrons and others.

1. Sketch between pages 72 and 73 of original.

Legend: Schematic map of the limits of distribution of certain Arctic animals.

2. South limits of the nesting of polar sea gulls.
3. Distribution of the snow owl.
4. Distribution of the tundra partridge
5. South limits of the nesting of the snow bunting,
6. South limits of the summer habitat of the Arctic fox.
7. South limits of the distribution of the white bear.
8. Area of the spread of the Arctic fox.

Without subdividing the animals further into ancient Arctic forms and

forms that came in after, because this could by no means be done in the case of all the species, we shall give a brief survey of the separate groups, dwelling in detail only upon the animals having economic (commercial) importance. In order to give an idea of the richness of the land fauna and the relationship between the separate groups of animals, we reproduce the following summarized data for Novaya Zemlya. Up to the present time we have recorded the following for Novaya Zemlya: simplest species -- 47 (of these 37 ungulates; sponges, 0; worms -- 100 (64 rotifera); mollusks -- 1; crustaceans -- 57; arachnida -- 55; insects -- 264 (of these lower forms of insects -- 21, coleoptera -- 31, hymenoptera -- 29, butterflies -- 20, and diptera -- 140); fish -- 3; amphibians -- 0; reptiles -- 0; birds -- 41 (7 which fly occasionally) and mammals -- 7. The number of species of mammals inhabiting the islands of the Arctic is very small. The Arctic fox, which is an important article of commerce, is found on all of the islands without exception. However, as a permanent inhabitant, making a hole and rearing its young, this Arctic fox is native chiefly to those islands on which there are lemmings. The inhabitants of the north have rightfully called the lemmings "fox mice," emphasizing in this way the exceptional importance of this rodent in the life of the polar fox. It is only when there is an abundance of lemmings that the pair of foxes can, during the short Arctic summer, feed their pups, which appear in the burrows in the early spring to the number of 6 to 18 and even 20. It is not easy to provide food for such a large litter. On the islands where there are no lemmings, for example on Franz Josef Land, we encounter the polar fox the year round, but it rarely burrows there.

The fur of the polar fox, which is a brownish-gray in summer, changes to a pure rich white in winter. Some polar foxes conserve their smoky-gray or brown color even in winter; in the fur trade such foxes are called "doves." The skins of the "dove" foxes are rare and have a much higher value than those of the white fox. The ordinary white fox, which is not noticed on the background of the snow, has such a thick coat of fur in the winter that even the severe Arctic storms do not blow through it. The short ears of the Arctic fox, his

strong feet and tail, which is shorter than in the case of the usual fox, are also covered with thick fur. Being protected from the cold and provided with long, sharp claws adapted for digging into the compact snow, the polar fox can "engage in single combat" with the long and highly severe Arctic winter. It continues active throughout the cold and dark period of the year and only during the heavy storms does it go temporarily into a snow burrow, where it stays until the bad weather clears up. The great fertility of the polar fox, particularly noticeable in comparison with the fertility of those living further south and the other foxes related to it, is also an element of adaptation to life in the north. Here it can survive and come out victorious in its struggle with the severe conditions of life only by being a fertile, omnivorous, active and mobile animal of prey.

Picture, p. 74. A polar fox in a trap.

In the fall and winter the polar fox makes long migrations, and, by moving over the marine ice, goes far into the depths of the polar basin. In addition to feeding on lemmings, the polar fox also eats the remains of the prey of white bears; in the summer it also eats fish, berries, eggs, nestlings and sometimes

even grown birds.

Another typical representative of the Arctic which is widely distributed is the white bear, but it visits some of the south islands (Vaigach, the south island of Novaya Zemlya, Belye and the islands of Yenisei Gulf) only in the winter and at the present time it goes to Kolguev only occasionally. The white bear spends a great part of his time on floating blocks of ice, on which it goes far away into the polar basin. In winter the white bears frequently travel towards the south, right up to the continent; a part of them, chiefly the females, lie in their dens until the spring.

Picture, p. 75. Bear at bay.

The den of the white bear, or, better said, the snow burrow, is generally made, not on moving ice but on islands and the littoral parts of the continent. There are a great many of these dens on Wrangel Island. During the period from the end of February to the beginning of March the bears lying in the dens bear one or two cubs (rarely more), and when they have become fairly strong they

begin to wander with them over the sea ice. The white bear is a large and unusually strong animal. The large old males weigh 700 kg (oftentimes there are individuals which weigh 300 -- 450 kg). Such an animal is able to carry for many meters large carcasses of dea walruses which the animal hunters can draw to the shore only with great difficulty. The white bear is a good and tireless swimmer, and it can easily make long trips over icy waters where there are countless ice drifts.

This rapacious animal lives by hunting and lying in ambush for marine animals, which, depending upon the movement of the ice and other seasonal hydrological phenomena, make rather long migrations. So the white bears wander constantly all of their life over the seashore and ice blocks.

The period of settled existence is the winter sleep in the den, a period which is longer for the pregnant females and the females lying up with cubs, coming chiefly in the winter. The males, which take no part in the rearing of the cubs, wander more extensively than the females and stay in the den for a very short time. The female bears have cubs once in two years; the average litter varies from one to three; in rare cases a female has been observed to have four cubs.

The white bear hunts chiefly for seals and other pinnipedia, attacking walruses rarely, because the struggle between them does not always end victoriously for the bear. In the summer, when it becomes more difficult to catch the pinnipedia, white bears feed on everything that they can find, even carrion, lemmings, bird eggs and nestlings. During the year they may even change over to a vegetable diet and eat seaweed, moss, and other plant food. With such food they deteriorate a great deal and lose all of their subcutaneous fat.

The wild reindeer have spread much less extensively over the islands of the Arctic, where man has exterminated them. They do not live on the islands of the Far North (on Franz Josef Land, Vize Island, De Long Islands, and Wrangel Island) and go to them (except Wrangel Island) on floating ice only occasionally. In summer, the northern reindeer wanders to the north, crossing from the continent

to the islands over the drift ice and even crossing straits and bays of considerable width, and in the wintertime it again comes south and oftentimes crosses to the continent. The islands of Koguev, Vaigach, and Novaya Zemlya have domestic reindeer.

On the main islands of the Arctic, with the exception of Franz Josef Land and the small islands of the Far North, there are two species of rodents: the pied lemming and the ordinary lemming, which serve as the main food of the Arctic fox and the polar owl. The pied lemming is the field mouse of the Arctic, an herbivorous animal: their food consists of plants, both the part above the ground and that under the ground. The presence of lemmings may usually be detected by the abundance of burrows and underground passageways which they make in the upper layer of the soil. These small animals do not go into hibernation, but spend the whole winter making long passageways in the snow in search of food. During the short Arctic summer many plants are covered with snow and are conserved until spring in a green state. This green forage, conserved by the cold, is fully sufficient to sustain the life of the pied lemmings. Protected from the severe cold by their magnificent fur, by the layer of snow and by the warm walls of their large winter nests, the lemmings can easily endure the long winter and oftentimes multiply in the cold and dark months of the year. As a rule these rodents are very fertile. In the years favorable for their breeding, many thousands of lemmings inundate the tundra of the Arctic Islands. In such periods they carry out a mass migration -- a change in the abode of animals which have over-multiplied and oversettled the tundra.

Hundreds of thousands of them suddenly leave the place where they are and move out in a disorderly manner in various directions, crossing on their way all kinds of obstacles, swimming lakes, rivers, and straits of seas. A multitude of lemmings perish on the way, and the locality is left desolate for a time. Sometimes, in years when there are large numbers of lemmings, an epizootic spreads among them, killing thousands. There are indications that some of the diseases of the lemmings are transmitted to the polar fox, sleigh dogs, domestic reindeer

and even to man. Two or three years after the epizootic or migration the number of lemmings returns to normal and the happening described is repeated.

In addition to the mammals enumerated, we should also mention the ordinary fox and wolf, whose occasional appearance, from the continent, in some of the south islands of the Arctic, has been recorded repeatedly. More rarely these islands have been frequented by a few gluttons.

For a complete picture we shall also mention the marine mammals, which it would be more appropriate to mention here. In the seas of the Soviet Arctic we have found 8 species of pinnipedia. Of these, 4 species come into the Arctic seas from elsewhere and have no commercial importance (from the west, the "ring" seal, and some of these
gray seal, and vituline seal go into the Barents Sea, and/into the White Sea; from the east, from the Bering Sea, the Histriophoca fasciata comes into the Chukchee Sea and even into the East Siberian Sea. Among the rest of the pinnipedia the Greenland seal has the most importance commercially. The White Sea sub-species of this seal forms a special herd and lives in the Barents, White, and
in February -- March,
Kara Seas. During the pupping and molting season,/the "White Sea herd" of Greenland seals gather for "lyinguup" on the marine ice in the area of Cheshkaya Gulf, the mouth of the White Sea and in the White Sea itself.

Picture, p. 78. Reindeer.

Thousands of these seals form a continuous mass along the edges of the ice field. From time immemorial the Russian people of the coastal region have made their living going out in artels on boats into the ice for the purpose of hunting grown seals-- male Greenland seals, grey seals--young seals and "whites" (pups)-- newly born, with white fleecy fur. Since the Soviets came to power a large industry has been organized here, one which makes use of steam ice cutters, reconnaissance by airplane, and artels of animal hunters having excellent bases on vessels. Every year we get from this place hundreds of thousands of skins and much valuable fat from the Greenland seals. After the close of the pupping and molting season herds of these seals go away towards the north, northwest and northeast. They pass the summer widely scattered, near the south edge of the polar ice and in the depths from Spitsbergen up to Novaya Zemlya and Taimyr. The main part of the Greenland seals of this herd feed to the north of the Barents Sea, where in the summer months the surface layer of water, in the absence of icebergs, is filled for a short time with numerous microscopic seaweeds and animals. This "vegetable plankton" attracts a mass of fish, which are hunted by many marine mammals.

The Greenland seal is an excellent swimmer, an animal of the open sea; it feeds on various pelagic fish and invertebrates, particularly shrimp. Hence, it rarely approaches the shores and never stays around them for very long.

The next in commercial importance is the walrus. As a result of being hunted so actively by man it has been exterminated in the south and west parts of its habitat and at the present time is found chiefly in the north and east. In historic times it came down as far as northern Norway, but now, in the limits of the Soviet Arctic, it is found from Franz Josef Land and Novaya Zemlya at least up as far as the New Siberian Islands (the limits of the distribution towards the east is still not known). Another subspecies of the walrus lives in the Chukchee Sea. The walrus is very powerful, but due to its great weight it is very clumsy and rather helpless on dry land. On the other hand, it is a dangerous antagonist in the water, not only for the white bear but also for man,

and can overturn any sloop without difficulty. The food of the walrus consists of benthic invertegrates (various mollucks) and for this reason it stays in shallow water. There are cases, however, when the walrus feeds on other pinnipedia, chiefly ringed seals. In contrast to other pinnipedia, the walrus oftentimes goes out on dry land and suns itself for hours. In certain places it arranges on the bank enormous "lying in" places which it inhabits from year to year.

In the seas of the Soviet Arctic there are two additional species of pinnipedia: the bearded seal and the ringed seal (floe rat (Phoca hispida), which are also fairly important articles of commerce. Both of these seals are primarily littoral animals, especially the bearded seal, which lives for a long time in some bay which it selects. In the course of the year both of these species make certain migrations, the "basis" (1) of which has not yet been fully determined. The food of the ringed seal and the bearded seal is fish and various benthic invertebrates.

Of the toothless whales there are six species, namely, the Greenland whale, the gray whale, the blue whale, the humpback whale, the finback whale, and the small rorqual (red whale), which come in to a greater or less extent from the Atlantic Ocean into the Barents Sea and from the Pacific Ocean into the Chuckchee; at the present time great inroads are being made upon some of them and at any rate none of them has any commercial importance in the limits of the western sector of the Arctic.

In the Bering Strait and the Chuckchee Sea the species of whales enumerated are still abundant and constitute articles of commerce. Among the toothed whales the beluga has great commercial importance; it is distributed from the White Sea and Barents Sea along all the Siberian littoral up to the Bering Strait and Chuckchee Sea.

(1) Principles to which they conform, or rules governing them.

This large dolphin, with a length of 4 -- 6 meters and a weight of up to 1 ton, has a skin of creamy-white color (the young are a dark grey, the half-grown are of a bluish-gray). The beluga moves about freely and prefers to remain in large groups. Each year belugas in herds of thousands make migrations from the Barents Sea into the Kara Sea and return, passing through Matochkin Shar (Strait) and Yugorski Shar (strait). A surprising picture is presented by the surface of the bays into which these large and powerful animals enter for a short stay. White shining backs appear and disappear everywhere, and we can hear their splashing and heavy breathing. After quickly inspecting a bay they generally go away just as suddenly as they appeared.

Belugas feed chiefly on polar cod, white fish, and salmon, and so they stay in the littoral waters and apparently go into the open seas very rarely. They do not fear the broken and scattered ice, but avoid continuous ice-floes and, hence, rarely go far beyond their edges.

Picture, p. 31. Children of hunters near a walrus carcass.

In contrast with the beluga, which is dying out at the present

time, the narwhale is found chiefly far to the north among the ice-floes; it is rather rare in all places, but is found throughout the polar basin. The killer whale, a large and extremely rapacious dolphin, is found in the Barents and Chuckchee Seas, rarely coming into the White and Kara Seas. Lastly, the small porpoise is common in Murman, and there are some in the White Sea.

Hence, there are only two real cetaceans that are characteristic of the present arctic seas, covered for the greater part of the year with ice (that is, the Kara, Laptev, and East Siberian), namely, the beluga and the narwhale, while the rest merely go into the Barents Sea and to some extent into the Chuckchee.

In comparison with the mammals, bird life in the Arctic is fairly well represented. There are a great many different kinds of birds on the continent, while on the islands the number of species is much smaller. This is particularly noticeable in the case of the land birds. The western littoral of Novaya Zemlya, with its 48 species of birds, is not at all characteristic in this respect: owing to the Nordkapp branch of the warm Atlantic stream, a number of sub-arctic and even more southern species come to its shores (for example, the Atlantic guillemot and the puffin, and occasionally birds of the forest area such as the magpie, and even birds of the forest steppe -- the roller). The birds of Vaigach Island also constitute an exception; due to the small width of the strait separating Vaigach from the continent, these species reflect all the features of the continental arctic fauna (for example, the pintail duck, and the shoveller live on Vaigach Island).

The birds of Wrangel Island have an entirely different character; here we have a number of species no longer found anywhere else on the islands of the Soviet Arctic, as for example, the white goose, nesting here in large numbers, and the raven. At the same time, we do not find on Wrangel Island certain species which are widely distributed on the rest of the islands (for example, the northern phalarope, the plover, snow bunting, white owl, sea gulls, pomarine jaeger, and other purely polar species).

There are very few birds which nest on all the islands of the Soviet Arctic

or at least that are to be found there at all times. The most characteristic bird of the high Arctic, the white gull, nests only on the islands of the extreme north and in its migrations it follows the white bears; it feeds at times on the remains of their prey, and hence it visits the south areas of the arctic seas only in the winter. A number of birds confine themselves to the south islands, going to the north only in places (such for example are the tern, a sub-species of the silver sea gull, northern phalarope, "kamnesharka," the plover, goose, and the brant, especially the black brant, eider duck, white and tundra partridges). Finally, a number of species are represented in the west by single species and in the east by other sub-species or related species, and very often within the limits of a single Siberian Sea, most often of all in the limits of the Kara Sea, they are not adjacent to each other (as an example of such species we may mention first of all the ordinary eider duck, and the eastern species closely related to it known as the East Siberian eider duck, and also the tridactyl mew and the thick-billed guillemot). Certain species of this group (for example, the sandpiper) penetrate from the west to the islands of the Kara Sea, while their eastern representatives are limited in distribution to the continent and are not found on the islands.

We should also note that the fauna of the Barents and White Seas has a much more southern character; this is explained by the influence of the warm currents and the direct connection with the Norwegian sea (for example, the following are characteristic of the Barents Sea--the sea gull, mew, loon, and the cormorant--but are absent in the rest of the seas of the Arctic. The same thing is true for the Chukchee Sea, penetrated by a number of sea birds from the Bering Sea.

The interior parts of the islands of the Arctic seem to be almost without life for a great part of the year, especially the islands of the Far North. It is only in spring and autumn that we may find here some flocks of geese flying past or migrating, assembling in flocks, or stopping to feed. Some animation is also brought by the period of the molting of the geese, when their wing feathers

fall and they lose the ability to fly. During this time the molting geese assemble in flocks and wander over the tundra in search of food. At the least alarm they scatter in various directions and hide among the stones in a very skilful manner. With the exception of these periods, we most often find in the interior parts of the islands a few pairs of snow buntings and marine sandpipers, and on the tundra lakes we may find looms. In other years we see white owls sitting here and there on projecting stones and rocks, hunting for lemmings. Closer to the seashore, on lakes, we may find broods of eider ducks; on the south islands we may find a number of other species of ducks, and also swans (small swans and more rarely whooping swans); on the tundra we find rapacious gulls hunting for lemmings, woodcock and other small birds, stealing eggs and nestlings, but chiefly taking the prey of other gulls. Snow buntings, which replace here, so to speak, our domestic sparrows, are particularly numerous near the habitations of man.

In comparison with this monotonous bird population of the tundras, the mass nesting colonies of birds on the cliffs of the seashore are particularly striking. In the north such colonies are called bird "bazaars." The bird bazaars are found not only in the Arctic but also far to the south, particularly in the Baltic Sea; in certain areas of the Arctic they are very grandiose. The largest bird bazaars, with the greatest number of species, are found in Novaya Zemlya, on Franz Josef Land and some in Murman. In the Kara Sea there are almost no bird bazaars, and there are only a few in the Laptev Sea. Such a distribution of enormous nesting colonies is due to the peculiarities of the hydrology and the distribution of marine animals furnishing food for the birds. Among the bazaar birds the auks and the "knoyugi," which are characteristic of our Far East, feed upon the small planktonic entomostraca; and the tridactyl mew, guillemots, and razor-billed auk feed on pelagic fish and to a smaller extent on benthonic fish.

The make-up of the population of the bird bazaars will differ with the area of the Arctic in which they are found. Very far north and over almost all the Arctic there are bazaars of razor-billed auks. Somewhat further south the razor-billed auks are joined by the tridactyl mews. On the south islands of Franz Josef

land and on Wrangel Island the make-up of the population of the bird bazaars is rather varied. Life in the bird bazaars starts about the month of June and ends at the beginning of September. The main birds of the bazaars spend the rest of the year in the open sea, migrating to the south as the polar ice advances.

On the small low islands and on the flat cape we observe another form of nesting in colonies. Here the birds nest not on cliffs but on the level surface of the ground. While in the bird bazaars the number of nesting birds runs into the hundreds of thousands, here, in these flat colonies, their number rarely exceeds a hundred. The population of the flat nesting colonies is made up of entirely different birds from what we have in the bird bazaars. Only the white sea gull nests in both places. Among the flat nesting colonies the ordinary eider duck has considerable commercial importance. The female duck builds her nest of down which she plucks from her breast and the under parts of her body. After the brooding of the ducklings the nests are gathered up and after they are cleaned of dirt and grease they furnish valuable eiderdown. There are large colonies of ordinary eider ducks and of East Siberian eider ducks in all the arctic seas; in the Kara Sea and the Laptev Sea this species is comparatively rare.

In passing to the other animals of the Arctic, we should note a feature that is very characteristic of the fauna of the arctic islands, namely, the complete absence on them of amphibians and reptiles. In the streams and bodies of water of the arctic islands there are no fresh-water fish. Among the fish coming into the fresh water from the sea we find only char in the majority of the islands. In addition, a kind of salmon and gasterosteid fish come into the rivers of Novaya Zemlya; the Coregonus sardinellus maris-albi and other fish come into Kolguev Island. Many catadromous fish of the Siberian rivers, such as the salmon, white fish, and others, do not enter the rivers of the majority of the islands of the Arctic (In the Bolshaya Karga River on Kotelny Island considerable numbers of Siberian salmon are caught. Large numbers of char are found in Khaastyu River and the lake of the same name on the island of Bolshoi Lyakhov; however, we have no information concerning their life and distribution in the arctic seas.

The invertebrates of the arctic islands have been investigated much less still. The most numerous representatives on them are the diptera, and the hymenoptera occupy second place (among these are the Ichneumonidae), and then come the coleoptera (chiefly the carnivorous forms -- Carabidae, Dytiscidae -- and particularly the Staphylinidae) and the butterflies.

It seems that the lower hexapoda ("polycaudata"), which are well represented, have as yet been investigated very little, and the same is true of the arachnoids. The predominant forms in the bodies of fresh water are the rotifera, crustaceans, and probably the rhizopods, the investigation of which has just been started. A very characteristic feature is the absence, in the fresh waters of the islands of the Arctic, of the Porifera, hydroids, and the polyzoa. Towards the north the fresh water fauna becomes extremely poor. For example, in the bodies of water of Franz Josef Land there have been discovered only 2 species of crustacea and 16 species of rotifera, while on Novaya Zemlya the numbers discovered are 57 and 64, respectively.

The fauna of the Soviet Arctic seas is richer than the fauna of the land.

The fauna of the bottom benthos is the most varied, and then comes the freely-moving forms of the water strata (plankton). The marine vertebrates, which we mentioned above, have the fewest representatives of all.

Picture, p. 85. Bird bazaar.

The chief animal mass of plankton is made up of various crustacea (the most important of these being Calanus finmarchicus, Pseudocalanus elongatus and Oithona similis), and also the crustaceous infusoria (as for example, the genus Parafavella for the open sea and the genus Tintinnopsis for the littoral waters). The characteristic Medusae of the arctic seas are the small hydromedusae (for example, Aeginopsis laurentii for all the layers of water and Ptychogastria polaris for the bottom layers of water.). The large Scythomedusae (as for example, Cyanea arctica and Aurelia aurita) are found only in the Barents Sea and the White Sea. We should also note two pelagic mollusks (Clione limacina, distributed over all of the arctic seas, and another, Spiratella helicina, reaching from the west only up to the western half of the Kara Sea) which, together with one crustacean (Calanus finmarchicus) constitute the basic food of the toothless whale. On the whole the distribution of plankton organisms is very closely associated on the one hand with the ocean currents and on the other with the distribution of fresh water brought into the arctic seas by the Siberian rivers. As a result of this, the distribution of plankton organisms changes not only from year to year but also from season to season. However, there is a certain uniformity in their mean distribution over a number of years, the general features of which are determined by the distribution of the benthos.

Almost all the basic groups of animals are represented in the benthos of the arctic seas, but quantitatively its basic mass consists of echinoderms (in particular Ophiurida serpentina), then mollusks (chiefly bivalvular) equipedal (isopoda) crustaceans and multisetaceous worms. The equipedal crustaceans are represented by large numbers of marine Blattidae (Mesidothea sibirica and Massabini, one of the characteristic denizens of the bottom of the arctic seas). The main part of the benthonic animals belong to the forms of the high Arctic, that is, to forms living as a rule only at temperatures below zero, but in certain regions of the arctic seas this general mass of high Arctic animal life is oftentimes penetrated or even driven out by forms of the moderate Arctic and even by forms of still warmer waters. This penetration of forms that are foreign to the Arctic

is accounted for by the presence of warm Atlantic currents.

In the Barents Sea the more southerly foreign (alien) fauna occupies all the southwest part; towards the east, northeast, and to some extent towards the north the southern species gradually drop out and are replaced by species representative of the moderate Arctic; and even on the western shores of Novaya Zemlya, in the straits of Franz Josef Land, and on the eastern shores of Spitsbergen there are representatives of the high Arctic (for example, the echinodern Ophiopleura borealis and the mollusk Portlandia arctica).

In the Kara, Laptev, and East Siberian Seas we have just the opposite picture. The high Arctic fauna of the shallow sea is conserved here without change, apparently since the time of the Quaternary glaciation (it is characterized by the representatives Portlandica arctica and Mesidothea sibirica), now close to the shores of the continent. Farther to the north, approximately in latitude 77 -- 78° there is an intrusion into these seas from the west to the east, with the waters of the Atlantic current, of some Atlantic fauna of the moderate Arctic (for example, Ophiura sarsi, belonging to the echinoderms; Calathura brachiata, to the crustaceans, and the Scissurella crispata, to the mollusks), which to some extent drives out the high arctic fauna. This intrusion of moderate arctic fauna is very intensive along the slope of the polar basin, and is accompanied here by the penetration into the Arctic of forms from waters that are still warmer. We must suppose that in these areas of the Arctic the high arctic fauna of the shallow water loses its former connection with the ancient deep fauna of the polar basin (as characteristic representatives of the depth fauna of the polar basin at the present time we may mention such forms as the "stalk-like" lily, Ilycrnus carpenteri, and the holothurian or sea cucumber, Kolga hyalina, belonging to the echinoderms; the Propeamussium frigidus and Mohni, to the mollusks; the Mesidothea megalura, to the equipedal crustaceans).

We have a different picture in the Chuckchee Sea, into which forms of the Bering Sea com in with the ocean currents. Here, the high arctic fauna of the shallow waters also presses close to the shores of the continent, but to the

north of it we have at first a moderate arctic fauna and even a warm water Bering fauna, and then follows the moderate arctic fauna of the Atlantic, and after this the subsurface fauna of the polar basin. It seems that the relationships existing between the faunas here are still more complicated, even including the appearance of new species, but at any rate certain representatives of the Bering fauna (for example, the Aleutian crab--Hyas coarctatus alutaceous) penetrate even into the East Siberian Sea and up as far as the De Long Islands.

Of the sea fish the most typical pelagic type of the Arctic is the polar cod (Boreogadus saiga), widely distributed over all the Arctic seas. As a result of its small size no attention was paid to it for a long time, but recently it has come to have commercial importance in the White Sea, near Cheshskaya Gulf and farther towards the east. Many benthic non-commercial fish, the total number of which reaches many dozens of species in the waters of the Arctic, are also very characteristic of our northern seas (such as Lycodes polaris L. agnostus, Ulcina olrici, Artediellus scaber and others).

However, the fish coming into the Barents Sea to feed from the more southern areas have great commercial importance, among these we should mention first of all the codfish, haddock, and various herring (Clupea harengus and Cl. harengus pallasi; however, the Bering Sea has permanent forms of the latter, namely, Clupea harengus pallasi mat. maris-albi). The codfish and haddock are bottom (benthic) fish, while the herring are pelagic.

After spawning, the Norwegian codfish, having grown thin, move towards the east and, feeding on the way, gradually travel from the Lofoten Islands, the chief spawning place of this species, up to Novaya Zemlya and even up to the western edge of the Kara Sea. The codfish feed on herring, on young codfish and benthic invertebrates. The cod is the main article of the catch of Soviet trawlers in the open sea and of the littoral small-scale coastal fisherman using hook tackle, near the shores of Murman.

The sea perch, staying at moderate depths of 150 -- 200 meters, and certain species of flatfish (such as the halibut Hyppooglossus hyppoglossus, the marine

turbot Pleuronectes platessa, etc.) are very important articles of commerce, while the wolf-fish or swine-fish and a number of other species are of less importance.

As a result of the pressure of warm Atlantic waters, observed during the last 15 -- 20 years, there has taken place an advance of many marine animals, including even fish, from the west towards the east.

For example, at the present time, codfish have penetrated in commercial quantities as far as Novaya Zemlya, going even to Baidaratskaya Gulf on the Kara Sea. Herring, haddock, and polar cod have reached Novaya Zemlya, as well as certain warm-water fish foreign to the Barents Sea (for example, mackerel --Scober scombrus, and even Scomberosox saurus). Haddock, pollock, and sea perch have penetrated into the White Sea. A number of comparatively warm-water fish have been caught in the western part of the Barents Sea (for example, the "molva" (Molva molva, Gadus poutssou).). This process of intrusion into the Arctic of sub-arctic and boreal species which are foreign to it appears in all the groups of animals, and in the Barents Sea the course of the intrusion runs from west to east in the southern half of the sea, and in the Siberian seas it runs along their northern limit, sending off from here a tongue towards the south along deep meridional troughs.

PHYSICAL-GEOGRAPHICAL DESCRIPTION OF AREAS

Franz Josef Land

The archipelago of Franz Josef Land occupies an area of 18,940 sq. km. The number of islands making up this archipelago has not been definitely ascertained, because more than 90% of the archipelago is covered with ice, but at any rate there are no less than 100 of them.

All the archipelago is divided by two straits -- the Avstriiski Strait and the Britanski Strait -- into three parts; the majority of the islands of the archipelago are in the middle part between these straits (canals). Two of the largest islands are to the west of the Britanski Strait: Alexandra Land and

Georga Land. Vilchek Land, Graham-Bell Island, La Ronsyer Island and a few smaller islands lie to the east of Avstriiski Strait.

On the whole the archipelago is a fairly level plateau with elevations between 100 and 400 meters above sea level (on Vilcheka Land up to 700 meters), which is separated into parts by deep and narrow straits. The general uniform relief of the islands is caused first of all by the geological structure of the archipelago.

At the present time the geology of Franz Josef Land is outlined rather clearly. The basis of the section is the Middle and Upper Jurassic clays. Upwards they are alternated by sands, sandstones, and conglomerates, with numerous remains of plants, indicating that the basin grew shallow towards the end of the Jurassic. On the eroded surface of the Jurassic deposits are continental Lower Calcareous formations---clays and sands with strata of brown coal, with an abundant flora, interstratified with basalt covers and tufas. After the Lower Cretaceous, the area of Franz Josef Land was subjected to very gentle folding having a north-northwest direction. In Quaternary time there were radial displacements which led to the formation of deep straits between the islands.

The Quaternary deposits of the archipelago are divided into marine and glacial. The period of maximum glaciation of the islands was preceded by the inward movement of the sea (transgression), which deposited clay and sand with marine fauna, found at the present time among the glacial deposits and under them. The epoch, which preceded glaciation, was characterized, apparently, by excellent climatic conditions, during which the islands were favorable for the northern reindeer, the remains of which are found at a number of points. Then followed the recession of the sea and the simultaneous movement of the glaciers, leaving traces in the form of a horizon of ground moraines, fluvio-glacial deposits (that is, the sedimentation of the water from the melting ice), lateral moraines and only in very rare cases in the form of terminal moraines, as a rule extending beyond the limits of the shore line of the islands. At the present time the sea is receding and the ice cover of Franz Josef Land is growing smaller.

lica e, p. 91. The shore of Rudolph Island.

The climate of the archipelago is influenced by opposing factors which determine its character. Since Franz Josef Land is in high latitudes, the northeast and east (due to the position of the archipelago to the north of the arctic front), the temperature of the air on the island should be very low, but even in the coldes months (February -- March) the mean temperature in Tikhaya Bay is only -23°, -- 24°. This is the result of the warming influence of the Barents and Greenland Seas.

The summer here is very cold: in this same Tikhaya Bay it is only in July and August that the mean temperature is somewhat above 0° (+ 1.4° and + 0.4° respectively), and on Rudolph Island only the mean temperature of July (+ 0.2°) is positive. This is due chiefly to the fact that the archipelago is surrounded on all sides, except the south, by marine ice, which also cogs the numerous straits and creates around the separate islands a continuous icy ring.

A characteristic climatic feature of Franz Josef Land is the wind regimen. The prevailing winds here are from the north, particularly in the winter, when they are characterized, in addition, by their great force (up to 8 meters per sec.). The velocity of the wind in certain cases amounts to 40 meters per second. The north winds generally cause a sharp drop in the temperature. But when they are

replaced by winds blowing from the south (from the Barents Sea) the temperature of the air rises at once, and in such cases we oftentimes have thaws. In the summer, northwest winds are rather frequent. There are many overcast days (in Tikhaya Bay the average is more than 62%, particularly in summer). More than 30% of the days are foggy; most of them are in June and July. The precipitation, amounting in the southern part of Franz Josef Land to 500 mm, gradually decreases towards the north; on Rudolph Island the precipitation is about 300 mm, most of which is in the solid form.

The climatic peculiarities mentioned above (chiefly the cold summer and the prevalence of solid precipitation) favor the intensive glaciation of the archipelago. As we pointed out above, most of the surface of the archipelago is covered by glaciers, the thickness of which reaches 150 -- 180 meters.

The most widespread form of glacier on Franz Josef Land is the glacial cap of "island dome," the greater part of which is depressed and oftentimes covers the low islands completely; in this case they drop off into the sea abruptly in the form of a solid wall of ice. On certain islands the ice sheet has a regular cupola-shaped form; in places uncovered nunataks (of basalt) project above it. In other cases (Zemlya Alexandra, Zemlya Georga, Northbrook Island, and others) the icecaps have the form of irregular cupolas which do not break off into the sea but extend out in the form of a tongue over the riparian plain.

In Franz Josef Land we many times encounter valley glaciers, which differ from the high mountain type in that, due to the low level of the snow line, they are fed not only from the glacier basin but also by solid atmospheric precipitation, which accumulates on the glacial tongue itself.

The valleys along which the glaciers move are generally trough-shaped and flat-bottomed. In these valleys we observe only lateral and medial moraines, while the terminal are carried by the glaciers into the sea. On the steep leeward slopes glaciers are formed from snowdrifts; they are characterized by their small dimensions, slow movement, and distinct strata, which are due to the yearly accumulation of drifted snow and the fine earth from the sectors located above.

The movement of glaciers on Franz Josef Land has been studied very little. Observation of the Yuria glacier on Hooker Island showed that the part of this glacier farthest from the lateral edges moves at a rate of 14 -- 16 cm per day.

Above we said that on Franz Josef Land there are signs of the subsidence of the ice cover. On the sectors where the glaciers are subsiding we observe smooth glacial forms of relief or lateral moraines on the surface of the islands themselves.

A good many icebergs are being formed on the shores of the islands of Franz Josef Land, and this exercises a greater influence upon the subsidence of the glacial cover than the melting caused by solar radiation.

Being a product of the local climate, the glaciers of Franz Josef Land exert at the same time an influence upon the latter, lowering in particular the temperature of the air during the warm season of the year. The ice cover makes of the archipelago a special uniform geo-morphological province. The snow-ice covered surface of the islands is generally a level plateau (the elevations vary within the limits of 100 -- 400 meters above sea level). It is only in places that we find rather high nunataks (for example, on the islands of Bruce and La Ronsyer). The rare ice-free littoral sectors are varied in character, but are generally terraced (the islands Ketlits, Hebel, Hooker, Zemlya Alexandra) and the glacial forms of relief here are oftentimes in the form of lateral moraines and troughs.

As a rule the shore line in the archipelago is indented very little; fjords are absent; the features in the way of fjords are deep and narrow fjord-shaped bays cutting deeply into the south part of Zemlya Georga.

In the limits of the archipelago there are two outstanding types of shore lines: 1) terraced, usually made up of basalts, and more rarely of sedimentary rocks, and 2) low shores, accompanied in places by a rather broad littoral plain on which we find polygonal, circular, or oval-shaped lakes fed by the melting snow and the glaciers.

On the shores free of land glaciers there are oftentimes marine terraces,

whose heights above sea level are 3.6 -- 10, 12 -- 14 and 25 -- 30 meters. Sometimes the terraced levels are even higher. It is probable that these are mountain terraces; on Mebel Island, for example, there are such terraces having an elevation of 120 meters.

On Franz Josef Land the work of flowing water is insignificant; hence, erosion valleys are encountered very rarely and are poorly developed.

At places where the mountain rock is naked as a result of intensive weathering, there is a thin, poorly-developed soil cover, and we notice a better development of soil-forming processes in sedimentary rocks than in the case of the basalts, particularly at the places of the greatest accumulation of fine materials.

The severe climatic conditions, the small depth to which frozen ground thaws in the summer (30 -- 40 cm in the littoral zone) holds up the development of the weak gley soils existing here. In very rare cases, on the slopes and as a rule on the drained sectors, we observe certain signs of a podzol process. A rather thick cover of vegetation is characteristic of these sectors. On the elevated sectors we encounter well-expressed polygonal formations; on the limits of the polygons, characterized by a moisture content that is smaller than in the central part of the polygon, the vegetation is scant.

The flora of the archipelago, as a result of its complete isolation and its extreme northern position and also as a result of the intensive glaciation, which covered all except small sectors of the dry land, is very scant. The chief representatives of the vegetable kingdom here are the lichens (about 100 species) and mosses (more than 80 species); phanerogamia -- about 40; the predominant plants are the polar poppy and various species of saxifrage.

The animal life of Franz Josef Land, in particular the land forms, is characterized -- and for the same reasons prevailing in the case of plants -- by the extreme poverty of species, even in comparison with the rest of the areas of the arctic dry land.

The most common land mammal is the white bear; the polar fox is very rare.

Picture, p. 95. Tikhaya Bay.

Even the lemming is absent, an animal which is so widely distributed over the Arctic islands (even in the tundra) and which in the other areas constitutes the chief source of food for the polar fox. The latter stray into Franz Josef Land on the ice-floes, because it is found on the floes even much farther north than the archipelago (in latitude 85° N). However, there are indications that a small number of polar foxes live permanently on the islands of the archipelago. At the present time there are no reindeer on Franz Josef Land, but apparently they are sometimes brought here by floating ice— this is indicated by the finding of several discarded horns. In the numerous straits of the archipelago and even in the seas adjacent to it there is a considerable number of walruses, seals (Greenland, "ringed" seal, bearded seal) and belugas; large herds of narwhales are also found.

In the summer large numbers of birds fly to Franz Josef Land, the number of species amounting to about 30. The most numerous are the ordinary auks and the razor-billed auks, many mews, tridactyl mews, fulmars, and white seagulls. These birds settle in large colonies on the rocky shores of the island, forming large bird "bazaars" (colonies), about 40 of which are known on the archipelago.

In addition to the birds living in colonies, the following kinds nest here: the snow bunting, brant, loon, eider duck, pomarine jaeger, tundra partridge,

sandpiper, and puffin. The polar owl is also found.

The insects of Franz Josef Land have been studied very little.

VICTORIA ISLAND

To the west of Franz Josef Land, at a distance of approximately 100 km, is the small island known as Victoria (80° 08' N. Latitude, 37° 00' E. Longitude), having a length of about 70 km and a width of about 2.5 km. The island is covered by a continuous ice sheet. The highest point of the ice "cupola" is at an elevation of about 100 meters above sea level, and the ice blocks end at the seashore in a steep wall whose height amounts to as much as 44 meters. It is only in one place at the foot of the ice cliff that we have a different picture. Here there is a stony slope of pebble of carboniferous crystalline limestones, dolomites, basalts and siliceous materials.

KOLGUEV ISLAND

Kolguev Island, occupying an area of 3,728 sq. km, is separated from the continent by a strait having a width of about 75 km.

The depths of the strait between Kolguev and the continent do not exceed 50 -- 55 meters. The island is a part of a shallow continental shelf projecting above the surface of the sea and surrounded by broad sandy shoals (the local name being "Koshkami").

The island is made up exclusively of soft Quaternary deposits; they are represented first of all by deposits of boreal transgression--clays with marine fauna, covered by sands also containing marine fauna and then by a ground moraine of the last glacial epoch--boulder clays, without any kind of sorting and with a maximum spread over the surface of the island. The accumulation of schistous boulder sands, conserved in the form of the aforementioned sopoks, took place at the time of the subsidence of the glaciers of this glacial period. Under the mmp deposits of the boreal transgression there is a bottom moraine, evidently due to

glaciation preceding the transgression. In post-glacial time there was an upheaval of the islands, showing itself in the river terraces and in the formation of the level surfaces of the north and south parts of Kolguev, representing marine terraces, stratified marine sands and clays.

The large central part of the island (approximately two-thirds of the surface) is occupied by a plain with "sopkas" (bald mountains) chiefly in three parallel ridges, which stretch from the southwest to the northeast. The most easterly of these ridges is the one characterized by high points.

The highest point of the island is sopka Savandei, which rises 170 meters above sea level and 77 meters above the surrounding locality. Between the hills and ridges there are deeply-cut river valleys.

The hills of Kolguev Island belong to two types: some of them, consisting of stratified boulder sands, were apparently formed in the period of the melting of the ice and are of glacial-river origin; the others, encountered rarely, are made up of boulder clays and are of purely glacial (or moraine) formation.

The south part of Kolguev Island is occupied by an ideally level lowland, a so-called "lapta" which reaches a width of 20 kilometers; this lowland is 3 -- 10 meters above sea level. The "lapta" described is a marine terrace dotted with numerous lakes of different sizes, in various stages of development; among them we find growing "lake basins" and even basins that are already drained of their water, a condition due to the slope of the plain towards the sea and the discharge of the water through the rivers and creeks into the sea.

A similar "lapta," but narrower, also exists in the northern part of the island.

The numerous lakes of Kolguev Island are different in origin: some of them are moraine lakes, others of the relict or lagoon type, and the third type represent accumulations of water on planoconcave sectors under which the eternally frozen ground is close to the surface. The largest lake here is Peschanoye Lake, on the eastern coast; it is 15 km long and 4 km wide; the lake is evidently of the relict type.

Many lakes are connected with each other by channels ("viskas").

The majority of the rivers on Kolguev Island, the largest of which is the Peschanka, rise near the west and northwest littoral area and have comparatively narrow but fairly deep valleys with terraces having the following heights: 3 -- 4, 7 -- 8, 11 -- 12, and 18 -- 20 meters.

The shores of the island are for the greater part steep and high, particularly in the northeast, where they reach 40 to 50 meters above sea level.

As a result of the predominance of the erosion work of the sea on the western shores in comparison with the east, Kolguev Island has acquired an assymetrical structure: its chief water divide is shifted a great deal towards the west.

The littoral formations resulting from marine accumulations (shore, embankments of pebble and sand) are rarely met with and are observed only on the south and east coasts. In some places we observe terraces having a height of 12 meters.

On the whole the shore line of Kolguev is rather smooth; it is not broken by any projecting capes of any note nor by any deep bays cutting into the island, if we except Promoinaya Bay, which is being gradually converted into a lake, evidently as a result of the elevation of the island.

The climatic conditions of Kolguev Island are determined by its northerly position (between 68° 47' and 69° 32' N. Latitude) and by the influence of the surrounding seas. During almost all of the two summer months the sun stays above the horizon, though it never gets very high above the horizon. If to this we also add the 60 days with "white nights," when the evening glow and the morning glow coincide, the total number of days with night illumination amounts to 115. In wintertime the sun does not show itself above the horizon for 54 days. Still there is no complete darkness in winter, because in the daytime there is crepuscular illumination from dispersed light. The area of Kolguev Island is characterized by its great amount of cloudiness (on an average 8.5). In summer the frequent fogs and cloudiness hold back the sun's rays, while in the winter they prevent excessive losses of heat by radiation, as a result of which the temperature

conditions on Kolguev Island are more moderate than on the nearby parts of the littoral area.

However, the climate of the island is determined not only by its position in high latitudes but also by the influence of the seas surrounding it and by the dry land which is nearby.

Being located near the continent, the island is under its strong continental influence; on the other hand, however, a moderating influence is exercised upon the climate by the warm waters of the Atlantic current, which bends around the island from the north and southwest. The cold waters coming in from the Kara Sea also exercise a considerable influence upon the climate. The area of Kolguev Island is under the prevailing action of the cold arctic masses of air; however, these masses of air are oftentimes replaced (especially in the winter) by polar (boreal) masses of air coming in from the west. The change in the air masses is accompanied by intense cyclonic activity.

Due to the influence of the seas the climate of Kolguev is more moderate than the littoral area of the continent located farther south. For example, the mean yearly temperature at the village of Bugrino (Kolguev Island -2.9°) is 1.5° higher than at Pustozersk (mouth of the Pechora). The temperature of the coldest month (March) at Bugrino (-13.8°) is higher by 5.1°, and the warmest month (August $+8.6^{\circ}$) is lower by 3.5° than at Pustozersk. The moderating influence of the seas shows itself especially in the yearly ranges, which on Kolguev (22.0°) are 8.6° lower than at Pustozersk.

The short and cool summer does not start on Kolguev Island until the second half of July and continues up to the middle of September; that is, it is not more than two months long, but even the summer months are not entirely free of frost.

In comparison with more southern latitudes, the summer is shifted towards the fall months, something which is generally characteristic for the Arctic, where a large quantity of heat is lost in the spring in melting the ice and snow; in the fall, however, the water heated up in the summer gives off its heat slowly and continues to warm the dry land for a long time.

The mean yearly quantity of precipitation on Kolguev Island, as measured by the rain gauge, is 262 mm, and the chief part of the precipitation falls in the summer in the form of frequent drizzly rains or snow. The actual yearly quantity of precipitation is no doubt greater. Almost three-fourths of the total precipitation falls as snow, which forms a cover for 222 days of the year.

In winter, during thaws, and during the time of strong winds, the snow is oftentimes covered with a hard crust known as glazed frost, which has a destructive effect upon the animals passing the winter, because it prevents them from getting their food from under the snow. For example, during the time of the glazed frost of 1932-1933 about 50% of all the reindeer on Kolguev perished. Owing to the strong winter winds and the snowstorms, the snow covers the surface very unevenly, and in places where there is no snow the ground freezes deep and, hence, eternally frozen ground is extensively distributed over the island of Kolguev. In places where snowdrifts generally occur and at times lie the whole year round, frozen ground is absent.

Owing to the moderate climate, the vegetation of Kolguev Island has the character of a southern variant of tundra. The vegetation forms a continuous cover, and undergrowth constitutes a considerable part of it. In number of species the vegetation is comparatively rich (227 species of vascular plants) and differs little from the adjoining parts of the continental tundra.

Marsh and meadow tundras are most widely distributed --- on gley-marshy soils; on podsol soils, on the tops of hills, made up of sands, and on the dry peat soils the lichen (reindeer moss --- Cladonia rangiferina) are widely distributed. On the low littoral areas flooded by the sea and at the mouths of rivers there has developed a peculiar kind of meadow growing on salt soils ("laide") with a special meadow vegetation.

The areas covered with reindeer moss, serving as winter pasture for reindeer, are of most economic importance. The excessive grazing of reindeer herds in the past has led to a considerable impoverishment of reindeer pastures. At the present time steps are being taken to restore them and to regulate grazing.

The summer period on Kolguev Island is characterized by an exceptional abundance of animal life, in so far as the number of animals is concerned, the abundance having no reference to the number of species. In the summer there is a great variety of aquatic birds in the tundra; they fill the air with their ceaseless noise. The majority of these birds build nests. On the seashore various kinds of gulls, eider ducks, loons, and even certain species of ordinary ducks nest in large colonies; on the lakes and rivers within the islands--various kinds of ducks, geese, and loons, and on the marshes and on the shores of bodies of water--- many snipes. In the interior bodies of water we find an abundance of various kinds of plankton organisms and fish, and the marsh vegetation also furnishes a sufficient quantity of food for the bird population. Birds appear on the island soon after the beginning of the spring thaws and fly away with the appearance of frost and the snow cover.

The only permanent feathered inhabitant of Kolguev Island -- the white partridge--stays in flocks in the summertime in the berry patches. The abundance of birds nesting on the island in the summer attracts a large number of birds of prey (hawk, white owl, etc.).

The only mammals found on the island are the polar fox and the ordinary fox. In the summer there is an abundance of food everywhere for the polar fox and, hence, during this time it generally stays near its den on dry sandy elevations. The wild reindeer, formerly living on the island, have now been entirely exterminated. From time to time a wolf comes to the island over the ice, but he is usually discovered quickly and destroyed. The reason for the complete absence on the island of rodents -- mice and lemmings--so widely distributed on the tundra, has not yet been explained. The frequent efforts at artificial breeding have resulted in failures. There are no reptiles or amphibians on the island.

The constant winds, frequent summer rains, and the low temperatures do not favor the development of "gnusa", which is so destructive of animals and man on the continental tundras. This is favorable for the raising of reindeer.

NOVAYA ZEMLYA AND THE ISLAND OF VAIGACH

Novaya Zemlya is the name given to the archipelago consisting of two large islands having a total area of 81,280 square kilometers, stretching over a length of almost 1,000 kilometers and separated by a very narrow strait, Matochkin Shar. In the immediate neighborhood of the two main islands of Novaya Zemlya there are a number of small islands, only one of which is of any size, namely, Mezhdusharski Island, lying near the west shore of the south island of Novaya Zemlya and having an area of 748 square kilometers.

On the south Novaya Zemlya is separated from Vaigach Island which has a great resemblance to it in geological structure, by Karskie Vorota (strait).

The most ancient deposits, paleontologically, on Novaya Zemlya are represented by the Lower and Middle Cambrian black clay schists and phyllites, outcrops of which are found only on the southern littoral of Matochkin Shar. Above this are layers of quartzites, phyllitic schists, sandstones and conglomerates of the Lower Silurian, outcrops of which are found at a number of points both in the north island and in the south island. A part of the diabases and of the diabase tufas are connected with this layer. On Novaya Zemlya there are a great deal of Lower Silurian limestones and schists, characterized by outcrops of diabases. After the deposits of Lower Silurian rocks there was a granitic intrusion of "Litiushev Kamen," the only one in the limits of Novaya Zemlya and Vaigach Island, and at the same time there was probably a phase of folding. The deposits of the Upper Silurian on Novaya Zemlya have been studied in great detail, and a great resemblance has been found between them and the corresponding deposits in England, indicating a connection between the marine bases of these areas in the given epoch. The section of the Upper Silurian starts with conglomerates, sandstones, and schists, replaced upwards by layers of limestone. Still higher are the lagoon sand-shale deposits, possibly belonging in part to the Lower Devonian.

The rocks of the Middle Devonian are represented by limestones, outcropping in the south part of Novaya Zemlya; on the north island they are replaced by

sandstone, schists, and tufaceous rocks, enclosing the remains of armored fish. The end of the Middle Devonian and the beginning of the Upper were marked by the outflow of diabases. Sometimes the diabase magma cooled before it reached the surface and formed thin sheet-like intrusions. The Upper Devonian includes the sandstones, schists, and limestones, which are developed both on Novaya Zemlya and on Vaigach. Above these are the Lower Carboniferous deposits, chiefly limestones, containing rich fauna. The section of the Paleozoic is terminated by a thick layer of sandstones, schists and limestones, which are characterized by the fauna of the Middle and Upper Carboniferous and the Lower Permian. The Lower Permian deposits seem to have a wide distribution, especially on the south island of Novaya Zemlya, where we observe an overthrust of them in the direction from the east to the west on all the more ancient formations. In the main, Novaya Zemlya and Vaigach Island were formed after the formation of the Lower Permian rocks. This structure is due in essence to the appearance of a large anticlinal fold constituting a branch of the Ural folding zone, complicated by a number of secondary folds, fissures and faults and in its axial part coinciding with the central zone of the island considered. The direction of the folding changes from the northwest on Vaigach Island and on the south of Novaya Zemlya to a northeast and even latitudinal direction on the north. The polymetallic (lead-zinc and copper) mineralization observed on Novaya Zemlya and on Vaigach Island have still not been sufficiently well correlated with the geological structure. Some investigators see a connection between the mineralization and the intrusion of Devonian and possibly Silurian diabases. However, the majority of geologists believe that the ore-bearing veins were formed as a result of the penetration, into the Paleozoic rocks, of warm mineral solutions due to the great intrusions of a formation of granites. The latter appeared in Upper Paleozoic time and still lie even now at a certain depth below the surface. Due to the fact that they are more readily accessible in comparison with the other areas of the Soviet Arctic, these ore deposits, especially on Vaigach Island, where their commercial importance is indisputable, have a great future.

On Novaya Zemlya the lead-zinc deposit of Mt. Vilczek merit our attention. As yet no other polymetallic deposits of any size have been discovered, fact which we may explain by the lack of geological investigation on Novaya Zemlya.

Mesozoic deposits have not been discovered either on Novaya Zemlya or on Vaigach Island in beds occurring at the place of origin, but on the other hand we find everywhere an abundance of rock waste of the Upper Jurrasic and Lower Cretaceous rocks with a rich fauna, indicating that the corresponding deposits were at one time developed on Novaya Zemlya, even though only in places, and that subsequently, in the epoch of the Quaternary glaciation and the Quaternary transgression, the Mesozoic layers, being looser, were entirely destroyed, there being conserved of them only separate boulders in the Quaternary rocks. The Quaternary deposits are represented first of all by glacial formations in the form of lateral, terminal, and ground moraines and deposits of glacial streams. In the epoch of Quaternary glaciation Novaya Zemlya and Vaigach Island were, without a doubt, entirely covered with continental ice moving from here towards the continent.

The detritus of the Novaya Zemlya rocks, encountered at many places in the limits of the Russian plain, enable us to determine the path along which the glaciers moved. The fact that Novaya Zemlya was the center, or at least one of the centers, of Quaternary glaciation was an obstacle to the accumulation within its limits of moraine materials, which in the main were transported towards the south. After the glaciation, Novaya Zemlya subsided a great deal, with alternating periods of upheaval, the extent of which is shown by the marine terraces on the shores of Novaya Zemlya, which rise up to 250 meters on the south island and up to 420 meters on the north island. The south island of Novaya Zemlya was, for the greater part, inundated by the sea. The traces of the recession of this sea, in the form of terraces, cut in the majority of cases in bed occurring at the place of origin, have been observed on the shores of Novaya Zemlya by all of its investigators. In the opinion of some of them, Novaya Zemlya in Quaternary time passed through two periods of glaciation, separated by an epoch of maximum submergence below sea level. However, this point of view cannot be regarded as

definitively proved. Assumptions have been made that all the marine terraces of Novaya Zemlya belong to a later and post-glacial epoch. A blanket glaciation preceded the formation of these terraces, and a secondary weaker renewal of glacial activity took place in the period of the formation of terraces having a height of 30 meters above the present level of the sea.

At the present time, about 25% of all the surface of Novaya Zemlya is covered with ice. The continental ice was spread chiefly over the north half of the north island.

The snow line on Novaya Zemlya drops in elevation in the direction from the south to the north: in the area of Matochkin Shar its elevation is about 600 meters; in the area of Mashigin Gulf it is about 450 meters; and near Cape Zhelaniya it drops down to 325 meters. The intensity of the glaciation increases in this same direction.

The parallel of Besymyannaya Gulf (72° N Latitude) must be regarded as the south limit of the present-day glaciation of Novaya Zemlya. Between it and Matochkin Shar there are separate and extensive firn fields, located in the central plateau of the island; here there are isolated groups of glaciers --the Penk glaciers. In the area of Matochkin Shar and to the north of it, up to Yuzhnaya Sulmeneva Gulf, we find chiefly cirque and hanging glaciers, which are undergoing vigorous degradation, usually not reaching the sea (on the west of the island); they drop down to elevations of 200 -- 100 meters above sea level. In Yuzhnaya Sulmeneva Gulf and to the north of it we observe thick glacial tongues, dropping down to the sea and fed by the glacier sheet in the interior part of the north island. In the area of Cape Zhelaniya, before we get to within 20 km of it, the continental ice gradually disappears.

In the western part of Novaya Zemlya only separate fairly large branches of central glacial shield reach the sea; in the north part of the Kara littoral of the islands the ice shield in one place drops off abruptly into the sea in the form of an ice wall stretching about 100 km (the Nordenskjöld glacier).

Sketch between Pages 104 and 105.

Geological map of Novaya Zemlya.

Legend: 1. Quaternary system, marine deposits; 2. Permian system; 3. Carboniferous system; 4. Devonian system; 5. Silurian system; 6. Igneous rocks; 7. Spread of arctic ice.

The maximum height of the ice cover of Novaya Zemlya, outcropping to the south of Mak Bay, reaches 1,000 meters, and the average height of the axial part of the shield is about 800 meters. A characteristic feature is that the ice divide here is shifted towards the east, in the direction of the Kara Sea.

Picture, page 105. Hanging glacier.

The thickness of the ice cover in its western part, as determined by seismic methods, is 400 — 450 meters, and here the continental ice fills the bays of the island to a depth of 150 — 250 meters. The ice cover of the north island of Novaya Zemlya consists of two ice "cupolas," marked off from each other (but not separated) by a depression in the area of Anna Bay; the north "cupola" is smaller.

The surface of the Novaya Zemlya ice cover, reflecting to a high degree the relief of the ice channel, is a combination of elevations and depressions. This

is the result of a decrease in the thickness of the Novaya Zemlya ice cover, which belongs to the subsiding type of ice cover; it is slightly active (rate of movement 100 -- 150 meters a year), and certain parts of it have even become separated from their feeding basins; the ice shield does not have any firn on it, and hence the ice base here is uncovered. The subsidence of ice on Novaya Zemlya is taking place very rapidly; due to this, many nunataks project through the glacial cover in the form of separate mountains and ridges, on the slopes and tops of which we may see boulders, ice scratches, ancient cirques. As a result of the recession of the glaciers, moraine ridges are left on the parts of the island that are becoming free of ice.

In those bays of the north island of Novaya Zemlya which receive the ice tongues there are formed icebergs of small dimensions; the greatest number of them occur on the western shore between Russkaya Gavan and Inostrantsev Bay.

Along the shores of Novaya Zemlya, particularly in the north of the island, there has been an extensive development of small glaciers from drifting snow.

The relief of Novaya Zemlya is characterized by its great complexity, which is due to the complicated structural geology and glaciation and also to the processes of weathering. In structure the surface of Novaya Zemlya is divided into the following areas: 1) the hilly plain of the south part of the island, 2) the middle part of Novaya Zemlya, with glacial forms of relief, 3) area of the ice shield, 4) terraced plain of the north part of the north island.

The hilly plain of the south part of the south island is between Karskie Vorota and the latitude of Bezymyannaya Gulf (the western shore of the south island). In the extreme south this plain is characterized by its uniformity; it is covered by numerous small lakes; its elevation does not exceed 100 -- 110 meters in the central part (the source of the Kazakovaya River). Gradually rising towards the north, the plain at 72° N. Latitude reaches an elevation of 400 -- 500 meters; in places even here there are separate flat crests.

Towards the Barents and the Kara Seas this central dividing plateau slopes down towards the sea and is cut by well-developed valleys of rivers and creeks

flowing into the aforementioned seas.

A large (the central) part of this area is a tectonic depression filled by Permian deposits. In the development of the present-day relief the chief part was played by glaciation and marine transgression: the traces of the latter in the north part of the area are found up to an elevation of 250 meters.

The middle part of Novaya Zemlya, between the parallels of Bezymyannaya Gulf and Yuzhnaya Sulmeneva, is a sector recently freed from the ice cover with residual glaciation in the form of firn fields in the south part and valley degrading glaciers, usually of the hanging types, in the middle and north parts.

In the area of Matochkin Shar the elevations reach 800 -- 1,000 meters, and the relief here (particularly to the north of Matochkin Shar) takes on a partial alpine character due to the dissection of the mountain massif by the young valleys; however, the tops of the mountains are worn down and flat; hence, we have here signs of a rejuvenation of the relief. The area described is characterized on both shores by the development of fjords. Between Krestovaya Gulf on the west and Neznayemi Gay on the east (south part of the north island) there is a valley running entirely through the island, namely, the Rusanov Valley.

Picture, p. 107. Relief of the central part of Novaya Zemlya.

In the area considered, the typical glacial forms of relief are troughs, cirques, and roches moutonnees.

The area of the ice sheet is located to the north of Yuzhnaya Sulmeneva Gulf. The only parts not covered by the ice sheet are the littoral sectors and the separate mountains located above it or between its valley branches. The largest of these, both in length and in height, is the Lomonosov ridge, reaching a height of 1,050 meters (town of Blednaya, in the area of Mak Gavan). In this part of Novaya Zemlya, the terminal moraines, consisting of several ridges parallel to each other (usually three), reaching elevations of several dozen meters, are particularly well expressed. The lateral moraines, bordering the valley glaciers, many times jut out relative to the front of the glacier and in many cases extend into the sea.

The terraced plain of the north part of Novaya Zemlya has a surface free of ice, gradually sloping towards the sea with well-expressed marine terraces. This sector, with a width of about 20 kilometers, constitutes the north slope of Lomonosov ridge.

This sector is characterized by a complete absence of any traces of glaciation.

The river network on Novaya Zemlya is weakly developed, particularly on the north island.

The erosion forms (valleys) of Novaya Zemlya may be reduced to the following types: 1) flat valleys with poorly-expressed relief formed chiefly as a result of the action of intermitted discharges of water ("wild" waters); 2) valleys of the ravine type, more or less rectilinear, carved by streams irregular even in summer, fed by "drift" glaciers (drift snow); 3) valleys with an undeveloped longitudinal profile, often U-shaped; in the littoral part they generally end in deltas; rivers flowing along these valleys have, in the summer, a more or less constant source of water, namely, the glaciers and the snow of the glacial zone; 4) valleys with a developed longitudinal profile; in the zone of present-day glaciation they are cut out in the form of troughs; many times there are meanders,

usually characteristic of rivers fed from lakes (of glacial origin).

There are very few lakes on Novaya Zemlya; they are found chiefly in the areas of present-day or recent glaciation; but in the littoral areas there are relict lakes resulting from the upheaval of the island.

The shore line of Novaya Zemlya is characterized by its highly indented character, which is due to numerous deep bays, most of which are typical fjords, extending into the island. This characteristic stands out sharply on the south and west shores, along which there are oftentimes small islands.

An essential characteristic of the shoreline of Novaya Zemlya (and Vaigach Island) is the agreement of its basic direction with the direction of the folds of the Paleozoic rock and at the same time with the direction of the chief axis of the islands. This fact expressly emphasizes the connection of the present-day configuration of the islands in question with their geological structure.

A very characteristic feature of the littoral of Novaya Zemlya is the almost universal distribution of the littoral plain (strand flat), oftentimes reaching a width of several kilometers. The strand flat generally descends to the sea in steep terraces having an altitude of 10 -- 20 meters. On the strand flat we find lakes (sometimes in large numbers). A large part of the rivers existing here (or a large part of the flow of the latter) are found on the littoral plain.

Picture, page 109. Glacial cirque.

All of the investigators of Novaya Zemlya have noticed here the numerous ancient marine levels, reaching on the north island "absolute heights" of up to 350 -- 400 meters.

It is curious to note that in the area of Russkaya Gavan there has been discovered at this elevation some fairly-well-preserved floating wood; this indicates an exceptionally rapid rate of upheaval unknown up until now in any other single littoral sector in the world. However, it is usually impossible to explain the ancient levels found in the various places of the littoral region of Novaya Zemlya; apparently the upheavals causing the formation of the islands took place (and are still taking place) very unevenly in their various parts. The most frequent sea levels present and having in the main the same elevations are the following: 2m ; 8 -- 10 m; 22 -- 25 m; 40 -- 42 m; 50 -- 55 m; 75 -- 80 m. Above these there are terraces with elevations differing widely in the different areas. It is probable that a second (Quaternary) post-glacial transgression reached here an elevation up to approximately 80 meters.

The young terraces (about 2 meters high), the relict lakes, the shore walls receding from the shore, the delta sectors of many rivers, and the young "bridges" between certain littoral islands separated from each other only a relatively short time ago are clear signs of a continuation of the upheaval of the islands.

The great length of Novaya Zemlya from north to south conditions the great temperature differences of its different parts. For example, in the extreme north of the north island, at Cape Zhelaniya, the mean temperature of each month, as well as the mean yearly temperature, is 4 -- 6 degrees (4 -- 6°) lower than at Malye Karmakuly, located on the south island. The mean temperatures at Malye Karmakuly and at Cape Zhelaniya are, respectively, as follows: in March (the coldest month) -15.5°, and -21.5°; in August (the warmest month), + 7.0° and + 2.4°; for the year; -4.6° and -9.3°.

The position of Novaya Zemlya between the Barents Sea and the Kara Seas causes a difference between the climate of its western coast, bathed by warmer waters, and that of the eastern coast, bordered by the cold Kara Sea; the

difference in temperatures between the two coasts is particularly noticeable in the wintertime, when it reaches almost 5° (in accordance with the data obtained by a comparison of temperatures at Cape Stolbovoi, in the western part of Matochkin Shar, and Cape Vykhodny at the east end of this strait).

The most outstanding and peculiar feature of the Novaya Zemlya climate consists in the unstable weather, characterized almost everywhere and always by strong winds. Here this is caused by the special conditions of the atmospheric circulation, conditioned by the geographical location of the Novaya Zemlya elevations mentioned above.

The air coming in from the sea encounters this elevation, flows over it and descends with a high velocity in a direction perpendicular to the main axis of Novaya Zemlya. These winds (southeast on the west shore and northwest on the east shore) are the prevailing ones on Novaya Zemlya. They many times attain the force of hurricanes (V. Yu. Vize says that separate gusts may reach 80 meters per second and more) and they are known by the name of "Novaya Zemlya 'bora' " (the local names are "vstok" and "stok "). In the cold season of the year the Novaya Zemlya bora blow very frequently.

Picture, page 111. River valley with steep rocks. Novaya Zemlya.

On the north island of Novaya Zemlya the above-described winds oftentimes have the character of foehns, sometimes causing a considerable rise in temperature even in the winter time (up to +6.0 degrees).

Overcast skies and fogs are typical features of the Novaya Zemlya climate; at Cape Zhelaniya the number of days without sun is 222 (in the summer season of the year clear days occur only by way of exception). At Cape Zhelaniya there are 112 days with fog; the maximum number of them occur in July and August.

The amount of atmospheric precipitation here cannot be determined precisely (because of the strong winds): for Malye Karmakuly the amount recorded is 258 mm for the year; the maximum precipitation occurs in the warm season of the year (especially in September), but it is also frequent in other months. On the north island snows occur frequently in the summer.

The soils of Novaya Zemlya have been formed chiefly on moraine or marine deposits. The deep freezing of the substrata during the winter season, particularly on sectors from which the snow has been removed, the shallow depth of frozen ground in summer (at a depth of 30 — 50 cm) in consequence of this and the excess moisture of the upper horizons of the soil, due to the large admixture of clay in the rock and the resultant slight amount of evaporation are conditions favoring the formation of marshy-gley soils, encountered very frequently in the south and in the middle parts of the island. The thickness of the peaty horizons of these soils is 15 — 25 cm, and below these we find clays of a greenish and bluish color. The slightly podzol soils with traces of gley, formed on the south island (Rogachev Bay), are under particularly favorable conditions from the standpoint of exposure and drainage.

On the most northerly and on the highest sectors there are no soils in the real sense of the word; here there is a prevalence of fragmental materials resulting from the weathering of mountain rocks and many times forming along the slopes, as a result of solifluction processes, the "stone" polygons usually found in the polar region. We also find polygonal formation on the Quaternary clays.

The character of the vegetation of the north island and a part of the south

(Trans. note: Page 120 not omitted, error of typist in numbering.)

island is that of the arctic desert; a large part of the south island forms a part of the subzone of the arctic tundras.

The chief plants of Novaya Zemlya, the ones "most easily contented" (hardiest (hardiest), and found everywhere on the mountain rock free of ice, are the lichens (crustaceous) and the mosses; the number of species of mosses is about 450. The number of species of phanerogamia is a little over 200. In the larger north part of Novaya Zemlya phanerogamia are generally found as single specimens: these are chiefly saxifrage, whitlow grass and polar poppies. It is only on the leeward slopes and at places where favorable conditions of exposure are combined with sufficient moisture that we observe small associations of the above-mentioned plants. Grasses (particularly aria -- Deschampsia arctica) and green mosses grow in places where there is sufficient moisture.

In the middle part of Novaya Zemlya, to the south of Krestovaya Gulf, we find sfagnum. The number of species of phanerogamia increases towards the south. The vegetation of the south part of Novaya Zemlya, forming a part of the subzone of the arctic tundra, is the richest. Just to the south of Matochkin Shar, on the western littoral of the island, we find sectors that have an almost continuous and fairly varied cover of vegetation, particularly well developed and reaching south of the parallel of Bezymyannaya Gulf (the most interesting in this respect being Gusinaya Zemlya). Here we often find peat-moss marshes. Among the lichens and phanerogamia we frequently encounter several kinds of trailing or creeping willows. On the extreme south of Novaya Zemlya we see dwarf birch. On the dry sectors of the south island there is an almost continuous cover of partridge grass (dryas).

The animal life of Novaya Zemlya is not characterized by a great variety. There are only five species of land mammals: the white bear, polar fox, two species of lemmings -- the Ob and the ungulate -- and the wild northern reindeer, found on the eastern and northern littoral areas of Novaya Zemlya.

Among the marine mammals living close to the shores of Novaya Zemlya and in its bays, we should mention the bearded seal, the "ringed seal" (or floe rat),

Picture, page 113. Strait of Matochkin Shar.

the Greenland seal, the beluga and also walruses, which recently have become more rare -- small herds or single specimens.

In the bodies of fresh water of Novaya Zemlya we find a single species of fish widely distributed namely, the char, which belongs to the family of the salmon; claims have been of the finding of Siberian salmon (omuls) in two rivers of the south island. The char is distributed over the western littoral up to Russkaya Gavan on the north and along the eastern littoral up to the island of Pakhtusovo and is a regular commercial article on the western littoral.

Novaya Zemlya has many bird "bazaars" (name given to bird colonies in the far north), located chiefly on the western shore of the island; we find them, but in much smaller numbers, also on the eastern shore, chiefly on its northern part. About 50 "bazaars" have been counted. The population of these "bazaars" consists of guillemots, which are the most widely distributed here; eider ducks, which have great commercial importance because they furnish a very valuable down; the tridactyl gulls, "burgomaster" gulls, auks and many other nesting birds to the number of about 40 species.

The nests of small swans, ducks, geese, loons, snipes and woodcocks are found around the lakes. The only bird known in the interior of the island, in its mountainous parts is the snow bunting. On Novaya Zemlya we find large numbers of polar owls, the enemy of the lemmings and birds nesting in bazaars. The invertebrate fauna is rather diversified, but is characterized by a complete absence

of certain orders; no orthoptera or odonata (dragon flies) have been found; the mollusks are poorly developed; land representatives are entirely absent here, and, of fresh water species, there is only one, the Pisidium conventus, which belongs to the gastropoda. It is interesting to note that we find "fluvial worms" on the island. There are a good many spiders, ticks, and coleoptera; there are a great many flies; the total number of species of insects is more than 250, one half of them being diptera.

Of all the islands of the Soviet sector of the Arctic, Novaya Zemlya has the largest population. Being a rather easily accessible part of the Arctic and having a large number of animals of industrial importance (the polar fox, marine animals, birds, char), Novaya Zemlya was settled long ago by Russian traders (chiefly from the coastal regions). The island also has a permanent population consisting of Nenets and Russians. The inhabited localities (not counting the temporary summer stations) number at the present time 17, 6 of which are polar scientific stations (Malye Karmakuly, Cape Stolbovoi, Vykhodny, Matochkin Shar, Russkaya Gavan and Cape Zhelaniya).

Vaigach Island (having an area of more than 3383 square kilometers) is located between Novaya Zemlya and the Yugorski Peninsula and is separated from Novaya Zemlya, of which it is a continuation, by Karskie Vorotoa Strait, having a width of about 45 km, and from the continent, by the narrow strait of Yugorski Shar. The length of the island is 105 kilometers and its width 44 kilometers.

Almost all the surface of Vaigach Island is a typical low tundra, with its characteristic lakes and marshy sectors. Along the island there stretch two residual ridges, parallel to each other and made up of "basic rock" (Paleozoic sand - clay and calcareous deposits); the highest sector, the so-called Sanin mountains, is in the south of the island, in its middle part; but even here the "absolute elevations" do not exceed 100 meters. A characteristic of Vaigach Island is the almost complete absence of rivers; in the meantime we find here some wide valleys without any streams (at least permanent ones). This interesting fact is explained to a certain extent by the rather flat relief and the

very limited area of the island, which, together with the strong winds, make impossible the accumulation, at the present time, of snow reserves which could feed the rivers. We should, however, bear in mind still another important circumstance, namely, the extensive development of karst processes, due to the extensive distribution of limestones; graphic proofs of the latter are the frequently observed arches and grottos near the shore, and also the big pits

Picture, page 115 - Shore of Vaigach Island.

located near the seashore and communicating by underground corridors with the sea.

The shore line of Vaigach Island on the east is characterized by smooth and slightly indented forms; but the other coast, in particular towards Karskie Vorota is highly indented by bays and gulfs extending far inland, for example, Dolgaya (in Karskie Vorota), having a length of 18 km and a width of 7 km, and also Lyamchina Gulf (on the southwest part of the island) with a length of about 12 km and a width of about 12 km.

Being the connecting geological link between Pay-Khoy on the south and Novaya Zemlya on the north, Vaigach Island has a great geomorphological resemblance to the aforementioned sectors.

THE ISLANDS OF KARA SEA

Over all the space of the Kara Sea there are scattered a good many small islands. Some of them are very close to the parts of the continent surrounding the Kara Sea or to the large island groups such as Franz Josef Land, Novaya

Zemlya, and Severnaya Zemlya. A number of the islands are located in the area of shallow water occupying the central part of the Kara Sea and cannot be connected either on the basis of geological or geographical characteristics with any large neighboring sectors of dry land. Among these are the following: Ushakov Island (80° 50' north latitude, 79° 30' east longitude), representing an ice cupola up to 25 km in length and 260 meters in height; Vize Island (79° 29' north latitude 76° 53' east longitude), not more than 20-25 km in length and 20m in "absolute altitude"; Uedineniya Island (77° 28' north latitude, 82° 20' east longitude), having an area of about 42 sq. km and an altitude of 20-25m above sea level, and, finally, the Sergei Kirov group of islands discovered by a geographical expedition of the Chief North Sea Route (Glavsevmorput) in 1935, and consisting of low (not over 50m) islands which are small in area.

With the exception of Ushakov Island, on which the channel of the glacier is probably at an altitude of not less than 100--150m, all the rest of the islands are residual mountains of quaternary marine terraces with a level surface and steep benches, intensively eroded by the sea, along the edges. An outstanding feature is constituted by the ancient terraced surfaces at elevations of 50, 20-25 and 10-15 meters. As a result of the erosion of these ancient terraces the present day shoals and sand banks were formed at their bases.

The structure of all the islands is approximately the same. On Vize Island there are outcrops of calcareous sandstones with fauna of Mesozoic appearance, which is found also at the bottom of the sea near the shores of Ushakov Island, which is entirely covered with ice. On Uelineniya Island there are outcrops of sandstones with seams of coal and the remains of plesiosaurs and wood of the Mesozoic period or rather of the Lower cretaceous Sands including seams of coal, sometimes of considerable thickness, are found on the Sergei Kirov Islands. These layers are crumpled everywhere into folds with a northeast direction. The quaternary sands amd clays with boulder materials and marine fauna are found everywhere. There are indications that an intensive upheaval of the shores is taking place at the present time; hence, we may suppose that not so long ago the

the majority of the islands mentioned were below sea level.

To the southwest of the Sergei Kirov Islands there is a small group of islands known as the Izvestia Tsik, on which there are outcrops of strongly metamorphosed shales analogous to the rocks of the Cambrian of the nearby littoral of Taimyr and Severnaya Zemlya. Finally, we should mention the islands of the Arctic Institute, apparently made up exclusively of quaternary deposits (marine and glacial). The elevations on these islands are of the same order of magnitude as those mentioned above and do not exceed 50m above sea level. The character of the surface leaves no doubt that these are quaternary marine terraces eroded at the present time by the sea.

The islands of Belye and Shokalsky, located in the extreme south part of the Kara Sea, are the direct continuation of those continental sectors close to which they lie. Both islands are made up of quaternary and sand-clay deposits. The island of Belye is a plain with low hills (10-12m) in the north and southeast, which slope steeply towards the sea.

The islands in the area of Yenisei Bay (Ovtsyn and Sibiryakov Islands and others) are flat sandy alluvial formations.

Dickson Island, built up of diabases, has on its surface mainly clay deposits. The height of the islands does not exceed 50m above sea level; its surface, as a rule, is slightly hilly. Sverdrup Island reaches the same altitude above sea level. This island is made up of the remains of a terminal moraine and has on its surface boulder materials of the west Taimyr rock (chiefly black clayey shale, diabase, granite, pegmatite).

SEVERNAYA ZEMLYA

The archipelago of Severnaya Zemlya consists of four main islands: Komsomolets, Pioner, Oktyabryskaya Revolyutsiya and Bolshevik, and a number of smaller ones linked to them. The total area of the archipelago is about 37,000 (square) km. The information which we have concerning it is still far from sufficient. All

the islands are separated from each other by relatively narrow straits, among which the only outstanding one is Shokalsky Strait between Bolshevik Island and Oktyabryskaya Revolyutsiya Island, which has a width of at least 25km and a depth of up to 250-390m.

In the limits of the archipelago the most extensive formations are the greatly transformed rocks belonging to the Lower Paleozoic. Their section begins below with clays and calcareous shales with layers of sandstone, sometimes passing into phyllites, quartzites and crystalline shales and having a thickness up to 700m. All this stratum (series of rocks) is conventionally referred to the Lower and Middle Cambrian. Above we supposedly have Upper Cambrian red and green sandstones, clays, and tufaceous shales alternating with effusions of quartz porphyries, the total thickness of which amounts to 2000m. Farther on there are motley colored marls, sandstones, clay limestones, and dolomites, also reaching a thickness of 2000m (supposedly belonging to the Lower Silurian). The next strata are represented by the Upper Silurian limestones with a thickness of about 1,000m. Upon these lie the motley colored marls, sandstones, and dolomites with seams and bosses of gypsum, having a thickness of over 1,100m and ending the section of the Lower Paleozoic. At places in the western part of the archipelago there have been conserved - in the form of separate abutments - grey and brown diagonally stratified sandstones with carbonaceous seams and the remains of plants, supposedly belonging, by analogy with Taimyr Peninsula, to the Permian and having a thickness not exceeding 100-150m. In the northern part of Komsomolets Island are outcrops of coal associated with these rocks.

All the layers are folded and the strike of the folds is in general meridional, with a deviation to the northeast in the south part of Severnaya Zemlya and to the northwest in the north part. On Oktyabryskaya Revolyutsiya Island we observe an overthrust of slightly dislocated deposits of the western part of the archipelago on the steep strongly crumpled folds of the eastern zone. On these islands certain masses of intrusive rocks--gabbro, gabbrodiabases and intersecting granites and granite-porphyries break through the lower horizons of the Paleozoic

(Cambrian?), but their mutual relationship with the younger strata is unknown. There is no doubt that much later, in the tertiary or even the quaternary period, there took place in the area of Severnaya Zemlya a vertical shifting of the separate sectors, conditioning the present-day outlines of the islands and the formation between them of deep straits such as Shokalsky and Vilkitsky Straits.

Picture, page 119

Cape Voroshilov. Severnaya Zemlya

Quaternary glacial deposits are found everywhere on Severnaya Zemlya. The island has moraine ridges, deposits of ground moraines, fluvio-glacial deposits and glacial rocks waste. By analogy with the adjoining parts of the continent we may speak of two phases of glacier movement. Apparently, the aforementioned phases were separated by marine transgression, the traces of which, in the form of remains of marine fauna, are found at elevations up to 70-100m above sea level. Not long ago there was a second transgression of the sea, the traces of which may be seen at elevations of 15-25m above its present-day level.

On the islands of this archipelago there are ice sheets spread out over the separate 41 seconnected sectors; it is only on Komsomolets Island that they come together in an almost continuous ice cover. The total area occupied by glaciers is more than 15,000 sq. km, that is, about 42% of all the area of the archipelago.

Table 12 shows the dimensions of the glaciers of the separate islands

Table 12

Name of the Islands	Number of Ice Sheets	Area of Island (km^2)	Area of Ice Sheets (km^2)	Percentage of Glaciation
Komsomolets	2	9244	6017	65.0
Pioner	1	1649	296	17.9
Oktyabryskaya Revolyutsiya	4	13922	6397	45.8
Bolshevik	2 (?)	11527	2471	21.5

The thickness of the ice sheets on the north sector of the archipelago does not exceed 200-250m. The ice supolas rarely reach the sea; in these cases (here and there on Komsomolets Island) we have ice cliffs 10-15m high. Sometimes the glaciers of the dry land gradually descend joining the marine ice blocks (with the shore land floes).

Tongues of ice move out from the ice sheets of the Oktyabryskaya Revolyutsiya and Bolshevik Islands into the valleys and fiords and reach the sea chiefly in the north; on Bolshevik Island there are only four or five such ice tongues reaching the sea.

The relief of the ice cover here is to a great extent a repetition of the basic relief; a feature of this relief is the terracing, found in places on the slopes of the ice cupolas, such as we observe for example on the north cupola of Oktyabryskaya Revolyutsiya Island. The coalescing tongues sometimes form a spur of ice (in Shokalsky Strait).

The activity of the glaciers of Severnaya Zemlya is very slight, it is only in certain places, chiefly in the north of the archipelago, that the movement of the glaciers can be detected at the present time, the fact that they do move being determined the presence on them of cracks, and also by the formation of icebergs. On the whole, however, the ice cover of Severnaya Zemlya is subsiding. In the earlier epochs of the Quaternary Period all the islands were no doubt completely covered by ice; at the present time only a few traces are left of a previous heavy glaciation, namely, some ancient moraine ridges, rock waste and separate sectors of fossil ice (in the valleys, fiords, on the slopes of the elevations), completely severed from the glaciers feeding them.

The geomorphological peculiarities of Severnaya Zemlya are due in large measure to the glaciation of the archipelago; the interior part of Oktyabryskaya Revolyutsiya Island, the largest area (about 14,000 square km.) and the highest in elevation (up to 675m above sea level in the area of Cape Voroshilov), is a worn down cupola. Bolshevik Island has a similar surface (its maximum elevation is a little more than 500m).

Map between Pages 120 and 121

Legend: Geological map of Severnaya Zemlya: 1 Quaternary deposits 2 Cretaceous system, 3 Permian system, 4 Silurian system, 5 Cambrian system, 6 Metamorphic rocks of undetermined origin, 7 Palezoic "acid" intrusions, 8 other igneous rocks, 9 Area of arctic glaciers.

Picture, Page 121

Tongue of a Valley Glacier.

On the basis of character of relief Komsomolets Island may be divided into two different sectors: a south sector made up of basic rocks, elevated and resembling in this respect Oktyabryskaya Revolyutsiya Island, and a north sector, which is larger and made up exclusively of quaternary deposits, chiefly glacial and, hence, constituting a flat hilly lowland.

On the whole Pioner Island is similar in relief to Komsomolets Island. The present outlines of Severnaya Zemlya are due chiefly to the Cenozoic radial dislocations; thus, the east shores of all the afore-mentioned islands and the

south shores of Bolshevik Island are limited by faults; Shokalsky Strait is a graben, and on Oktyabryskaya Revolyutsiya Island we observe meridional fault scarps with an amplitude decreasing towards the west, conditioning the general slope of the surface of the island in this same direction. The shore line of Severnaya Zemlya is characterized by its variety of forms. The western shores of Oktyabryskaya Revolyutsiya Island, in contrast with its eastern shores, are low and highly indented by a multitude of lagoons and bays which alternate with an abundance of shoals and similar formations. On the steep eastern shores there are a good many fiords, the largest of which is Matusevich (length 60 km). The western and eastern shores of Bolshevik Island are straight, steep, and high (up to 300-400m). On the western shore of this island we find in places small fiords having a length of not more than 10-15 km; on the north shore of Bolshevik Island the steep "basic" slopes are separated from the sea by a broad terrace, gradually descending, with an elevation of about 50m above sea level, and passing into the low dissected shore. The north shores of Komsomolets Island in conformity with the low relief, is greatly dissected; the south shores of this island regarded as belonging to the "sea cliff" type. Along the shores of Severnaya Zamlya we find terraces, among which the particularly distinct ones are those having elevations of 15-20, 30-40 and 90-100m above sea level; they are analogous to the terraces observed on the north littoral of Taimyr Peninsula.

The hydrographic network of Severnaya Zemlya is weakly developed and revives only in the period of the spring thaws. The largest number of small streams are found on Oktyabryskaya Revolyutsiya Island, where they are fed chiefly by the melting of the glaciers and the snow that covers them. Almost all the rivers of the island have deep canyon-like valleys. The stream network on Bolshevik Island is still less developed, and on Komsomolets and Pioner Islands there are no large streams at all.

The position of Severnaya Zemlya in the midst of the Arctic, between cold seas (Kara and Laptev) closely resembling each other in climate, conditions here peculiar climatic feature not observed on other polar islands (excepting Henrietta Island), namely, exceptionally stable temperatures of the air in winter and in summer. In accordance with the data of the station, on Domashny Island (in the Sedov archipelago), the winter here is characterized by mean monthly temperatures that are very close together-- from December to March (inclusively). The coldest month is December (-25.5°); the warmest July (0.6°). Of all the arctic islands only Rudolph Island has a colder summer than Severnaya Zemlya (on Rudolph Island, in July, which is the warmest month here, the mean temperature is only 0.2°). During the summer the sky over Severnaya Zemlya is for the most part overcast and there are frequent fogs; the precipitation which falls is chiefly in the solid form and small in amount; and the thickness of the snow cover is apparently not more than 20-25 cm, not counting the sectors favorable for the accumulation of snow, that is, the depressions and places protected from the prevailing winds.

Picture, Page 123

Island of Oktyabryskaya Revolyutsiya, Severnaya Zemlya

The small amount of atmospheric precipitation is not sufficient to maintain the glaciers of Severnaya Zemlya even at their present size and judging from numerous traces of former glaciation they are most clearly subsiding at present and have been for a rather long time; there is still some activity of glaciers taking place, chiefly in the north of the archipelago where they reach the sea in places, forming icebergs.

The vegetation of Severnaya Zemlya has been studied scarcely at all. It is claimed that it is found chiefly on the clay-sandy ground of the littoral plain and on the terraces, forming disconnected sod and bordering spots of naked soil; it consists of mosses and in the way of lichens; the phanerogamia we find the polar poppy, partridge grass, forget-me-nots, and others; grasses are also

present; in the most favorable places we find the polar willow.

The animal life has a number of peculiarities. Severnaya Zemlya has a great many white bears, a beast of prey, getting its food from the sea ("ringed" seal, bearded seal), but it is very poor in land mammals. The northern reindeer is rare here and stands the severe winter with great difficulty; the number of these animals is supplemented by small herds crossing Vilkitsky Strait now and then over the ice, in their summer wanderings from Taimyr.

There are also fewer polar foxes than on Novaya Zemlya; what we find are chiefly wandering individuals coming from the south. About 20 species of birds are found here; these are chiefly aquatic birds (razor-billed auks, ordinary auks, guillemots, white seagulls, eider ducks, fulmars and brants). There are no tundra partridges at all. The marine mammals are represented by many "ringed" seals, bearded seals, and belugas; the walrus and Greenland seal are rare.

THE NEW SIBERIAN ISLANDS

The New Siberian Islands, occupying an area of about 36,000 square km may be divided into two groups on the basis of the geographical arrangement of the separate islands: 1) the Lyakhov Islands, consisting of Bolshoi Lyakhov, Maly Lyakhov, Stolbovoi, and Semenovski 2) the New Siberian Islands proper, or the Anzhu Islands, comprising Kotelny Island and Faddeevski Island connected with it by Bunge Land, Novy Sibir, and Belshevik Islands. The New Siberian Islands are separated from the continent by Dmitri Laptev Strait, having a minimum width of 50 km.

Kotelny Island gives us the best idea of the geological structure of the New Siberian Islands. The geological section of Kotelny Island begins from below with coral limestones (in the central part of Kotelny Island), containing Upper Silurian fauna. On the west shores of Kotelny Island, and possibly in the interior of the island also, the Upper Devonian limestones and shales are present. The dark limestones, terminating the section of the Paleozoic of Kotelny Island, and supposedly of Kotelnyi Island, belong to the Middle Carboniferous.

The Paleozoic deposits of Kotelny Island are crumpled into inclined folds having a north-northwest direction. The Upper Triassic clay shales lie at several points on the Paleozoic of Kotelny but without conformity. On the Balyktax River the Triassic is covered by the Upper Jurassic ferruginous sandstones, which are in turn covered by ferruginous shales with rich flora belonging to the Upper Jurassic or to the Lower Cretaceous. The Mesozoic deposits of Kotelny Island are displaced much less than on Bolshoi Lyakhov, and Stolbovoi Islands, where they are crumpled into steep folds with a northwest direction and are broken through by intrusions of granites and granodiorites. Apparently, the south islands are in the zone of intensive Mesozoic folding, whereas the north part of the archipelago belongs to a more stable mass, affected only slightly by the folding movements of the Mesozoic, and at the earliest by those of the Lower Cretaceous. Simultaneously with the folding it is probable that there was an intrusion of granitoids, with which certain seams of rocks are connected (Bolshoi Lyakhov Island). On Kotelny Island there are well-known outcrops of liparite, the age of which is entirely unknown. Apparently, the seams of diabase and variolites of Kotelny and Bolshoi Lyakhov belong to the Mesozoics.

Picture, Page 125

Hanging Valley

The youngest of the prequaternary deposits are the sands and clays with the layers of brown coal and with such abundant remains of wood that the elevations containing them in Novaya Sibir have been given the name of "wood mountains". The plant remains of these layers belong to the Paleogenic or to the Upper Cretaceous. In addition to being found on Novaya Sibir Island tertiary deposits in the form of separate spots are also conserved on Kotelny Island. They are displaced everywhere with the form of sloping folds. At no place does the tertiary brown coal from deposits that have industrial importance, but, of course it is possible that such deposits may be found in the future.

The quaternary deposits of the New Siberian archipelago are highly varied and have been studied much more than deposits of similar age on the neighboring parts of the continent. The base of the quaternary deposits of the archipelago is constituted by fossil ice having a thickness up to 80m, which at the present time is regarded as the remains not of glaciers but of firn fields accumulating during the Ice Age in grabens. The ice is covered by various deposits, which may be divided into lake, terrigenous, diluvial, the deposits of streams and, finally, marine deposits, present only on the north islands of the archipelago. In these deposits we find many remains of quaternary mammals such as the mammoth, rhinoceros, horses, bisons, northern and Canadian reindeer, musk ox, tigers, and also remains of wood, indicating the presence of forests at this time up to latitudes 74°-75' north latitude. The tusks of mammoths in the quaternary deposits of the New Siberian Islands are found in such quantities that they constitute unique and useful deposit the mining of which is a paying business.

In regard to the quaternary history of the archipelago we may speak with certainly at the present time only of presence in quaternary time of a single important "period of cooling" (glaciation), causing the formation of buried ice and a following epoch of higher temperatures. The latter epoch was the time of the flourishing of the post-quaternary flora and fauna on the islands and in the north of the archipelago - the marine transgression. Following this there was apparently a second more moderate period of cold after which the islands were separated from the continent.

The prevailing form of relief in the New Siberian Islands is comparatively low flat type, due to a very extensive distribution here of a thick layer of quaternary deposits, in particular of fossil ice, and also to intensive denudation processes. The highest part of Novaya Sibir Island - the "Derevyannye Mountains - does not exceed 80m in elevation; Faddeevski Island is just as low. A particularly characteristic feature is the lowland constituting a sandy area (Ulakhan-Kumakh), partially flooded by the sea and located to the west of Faddeevski Island (the western part of the lowland is called Bunge Land). The

maximum elevation of Kotelny Island (the central elevation Malakatyn-tas) is 240m. On Maly Island the elevations reach 60m and on Stolbovoi Island they reach 100m (E. Toll). The highest features in this group of islands are the granite massifs of Bolshoi Island where Khanta-gai-tas Mountain reaches an elevation of 290m above sea level.

A characteristic feature of the mountainous sectors of the New Siberian Islands, made up of ancient eruptions and sedimentary rocks, is their lack of connection. This is explained by the fact that the above-mentioned elevations appeared as a result of young faults. Nevertheless, in the arrangement of these table-like granitic masses on Bolshoi Island we may note a certain regularity: they form on the whole a single system, parallel to the south shores of the islands, forming here the south watershed of the latter. The second basic watershed of the island is in the north, along whose shores there also stretches a ridge almost parallel to the south one. In connection with this arrangement of watersheds we find a symmetrical-feathered distribution of the hydrographic network of the islands. We should also note that the rivers here are characterized by distinctly expressed meanders and by broad valleys; this is true even for the short rivers flowing from the south watershed into the Strait of Dmitrii Laptev. The above-mentioned massifs of Bolshoi Island, being horsts, are limited by fault lines, which have created the great interior graben, where the perennial ice is located. This interior part of the island is an area of small flat-bottom depressions, which are separated by elevations of 15-20m, made up entirely of perennial ice; in the flat depressions the ice lies deep and is covered by thick sand-clay deposits with remains of peat, wood, and mammals.

The basic features of the relief of Kotelny Island are also conditioned by the terraced faults having here a northeast and northwest direction. The rivers of Kotelny Island, flowing from the central elevation of Malakatyn-tas, form a radial hydrographic network. The largest one here is Balyktak River.

On the other islands, made up of uniform quaternary rocks, no regularity

has been observed in the distribution of the hydrographic network. Investigators of the New Siberian Islands have observed an exceptionally wide distribution on them of a good many shallow lakes which have no outlet, encountered on the water divide sectors and very often arranged on the fossil ice itself; oftentimes we find ravines most of which are located where there is contact between the quaternary rocks and the basic rocks replacing them in a horizontal direction.

Due to the eternally frozen ground and the small amount of atmospheric precipitation the steady flowing river network is on the whole poorly developed; it is only in the spring that the streams reach considerable dimensions.

The character of the surface of various forms of relief in the limits of the archipelago is conditioned first of all by the intensive denudation. The chief factors here in the denudation of the horsts are wind corrasion and frost weathering which create various kinds of fantastic figures and wide depressions in the rocks. In the grabens, due to the presence here of fossil ice, the basic role in the formation of the relief has been played by the melting of this ice as a result of the deep penetration of relatively warm water. Besides, if the flow water from melting ice is absent or retarded, lakes having a peculiar history of development may be formed on the surface of the fossil ice. At places where the water from melting ice flows away without any obstruction there is left at the place of melting earth inclusions, characteristic of fossil ice, forming separate masses of earth, the so-called "baidzharakhi" (See page 129).

Hence, the New Siberian Islands are characterized by their thermokarst processes, very strongly and clearly developed on the shores of the islands, in the structure of which fossil ice has played a part. Such shores are eroded very quickly; for example, during the last quarter of a century the island of Vasilevsky has been worn down and converted into a shoal. However, simultaneously with the decrease in the area of certain islands we observe in places a growth in the area of dry land, due to the upheaval of the islands which is taking place at the present time.

In a climatic sense the New Siberian Islands are characterized by phenomena

which are conditioned by the influence, on the one hand, of an extensive continent located to the south and, on the other hand, by a rather large glacial oceanic space surrounding these islands. The most important results of such a position is the fairly regular change in the winds which occurs here: on Kotelny Island, in the summer, we observe a prevalence of winds from the north, in the winter, from the south, that is, a change of winds associated with a system of winds resembling monsoons, characteristic of the north edge of the continent. On the islands located closer to the continent, the influence of the latter is shown in the temperature conditions; for example, the temperature of the coldest month is lower here than in the north; the mean temperature of January on Bolshoi (Lyakhov) Island is - 31°, on Kotelny Island it is - 29.4°; on the other hand, the reverse is observed in summer: Bolshoi (Lyakhov) Island has a temperature of the air that is higher than on Kotelny Island (the mean temperatures of July are respectively 3.7° and 3.2°; in August, 3.4° and 2.4°; on certain summer days it even exceeds 22°).

Map between pages 128 and 129.

Geological Map of the New Siberian Islands.

Legend: 1 Quaternary system, 2 Marine deposits of the quaternary system 3 Paleogenic 4 Mesozoic 5 Jurassic 6 Triassic 7 Carboniferous System 8 Devonian System 9 Paleozoic System 10 Silurian System 11 Igneous Rocks.

Picture, Page 129

"Baidzharakhi"

The differences in temperatures of the air on the two aforementioned islands are caused not only by the influence of the continent on the climate of the islands located rather close to it, but even more by the oceanic character of the climate of Kotelny Island.

In the warm season of the year there is a great deal of cloudiness on the New Siberian Islands and a good many fogs in July. During this time up to 2/3 of the days are overcast and foggy.

The quantity of atmospheric precipitation is not great; it is about 200mm a year. In spite of the fact that a great part of it falls in the form of snow, the latter forms here only a thin layer which is easily blown away; the character of the relief and the great force of the wind favor the blowing away of the snow. As a result of this, favorable conditions are generally present in the New Siberian Islands for the formation of spots of naked soil and polygonal formations and also of stone rings and stone strips on the slopes, all of which are characteristic of the Arctic.

The low temperatures, slight evaporation, and particularly the shallowness of eternally frozen ground, conditioning the excessive moisture, create conditions which are exceptionally favorable for the formation of soils of the podzol type but which make possible the existence of peat-gley soils, appearing in places on the friable quaternary rocks and having considerable thickness. A great deal of marshiness is characteristic of the most northerly of the islands of the New Siberian group. On surfaces where compact rocks outcrop on the surface a detritus base is possible for the formation of soil.

The above described climatic and soil characteristics conditioned the typical feature of the vegetation of the New Siberian Islands, namely, its lack of continuity everywhere.

Usually, plants are found in small separate groups and very often they are found in the fissures between the polygons of the clay soil. Here mosses and lichens are the prevalent forms and among them there are scattered sedge and grasses (Alopecurus abpinus and others), saxifrage, polar poppy, cinquefoil (Potentilla), crowfoot, and certain other rare forms

On the level sectors and on the flat slopes with shallow soils there are mossy spots of tundra with grasses and sedge. On the moist slopes sedge often forms "mounds" rising among the moss and lichens of the plant cover.

On the drier sectors, protected from the winds, in addition to mosses and lichens we also have groups of Phanerogamia (Whitlow grass, polar poppy,

saxifrage, cinquefoil, crowfoot and spoonwort).

In the best protected places of the slopes, with a south exposure, there is a great variety of grassy plants. On dry slopes covered with detritus and not protected from the wind the prevailing forms of vegetation are mosses and crustaceous lichens, while the phanerogamia are very rare and found as single specimens; they are entirely absent in open mountainous relief.

The animal life of the New Siberian Islands is not characterized by its great variety of species, in comparison with the other arctic islands; on the contrary, certain animals , which are widely distributed in the more westerly areas of the Arctic, are unknown here.

The usual land mammals are the Ob lemming, polar fox (the most important commercial article), and the northern reindeer, which migrates to the island every year but only during the summer period.

In the fall the reindeer return to the continent; the reindeer go to the islands and return on the ice floes, which cover the straits. The white bear oftentimes stays in dens on the shores of the islands and is usually found on the ice floes during the period of its migration.

The waters bathing the archipelago are comparatively poor in marine animals; the only animal found here in large numbers is the ringed seal; the walrus has been observed here. For the region of the New Siberian Islands there is no information concerning the Greenland seal, bearded seal, and beluga so widely distributed in the Kara Sea and Barents Sea, though it is probable that separate individuals go there (the Greenland seal is found in the Laptev Sea, near Severnaya Zemlya). The fish of Laptev Sea have been studied very little; available information indicates that here the number of species is much smaller than in the Kara and Barents Seas. Among the fresh water fish we should mention the ground gudgeon, the navaga, and omul (a kind of salmon).

The bird population is also poorer than on the western islands. Bird bazaars, consisting chiefly of guillemots and razor-billed auks, have been observed even

on the most northerly islands but these bazaars are few in number. On the New Siberian Islands we find duck (eider ducks), geese (generally black and white billed brants, many tundra partridges, the usual snow buntings and white owls.

The insects (chiefly diptera) have been studied scarcely at all.

There is no permanent industrial population on the New Siberian Islands; artels of hunters (Yakutians, Russians, Yevenkis), usually to the number of several dozen men, come here from time to time for trading purposes (chiefly polar fox, sometimes reindeer). In winter they engage in the polar fox "industry" and in the summer they hunt birds and reindeer and catch fish. As an incidental activity they gather mammoth bones.

The permanent population consists of employees of the New Siberian polar station -- on Bolshoi (Lyakhov) and Kotelny Islands.

THE ISLANDS OF THE EAST SIBERIAN SEA

1. The De Long Islands. This group consists of Jeannette, Henrietta, Bennett Vilkitsky, and Zhokhova Islands.

The most characteristic feature of all this group of islands is constituted by the high abruptly rising mountain massifs, made up of young basalts and partially "enveloped" by present-day glaciation.

The most ancient rocks are the outcrops of Cambrian chloritic and micaceous shales on Bennett Island and the dark shales of the Lower Silurian which cover them. Up to the most recent date it was thought th t these layers were horizontal and that consequently the De Long Islands were platform formations limited on the north by the Chuckchee-Verkhoyansk Mesozoic geosincline. However, at the present time we may assume that the Lower Paleozoic of De Long Islands was dislocated and in all probability with the same degree of intensity as the Paleozoic proper of the New Siberian group of islands. The Mesozoic formations, including the carboniferous deposits, are younger. The eruptions of young basalts, oftentimes almond-shaped, making up almost all of the De Long Islands (with the exception of Henrietta and Jeannette Islands), have numerous faults, causing the formation of a number of horsts and graben over all the territory

of the archipelago and conditioning certain pecularities of the present-day relief.

Bennett Island, in its upper flat part, is covered with firn, which feed the glaciers moving towards the sea; on the south shore the latter terminate before reaching the sea.

Henrietta Island (area of about 14 sq. km). Almost half of this island is covered by an ice sheet. The highest point of the "shield" (and of the island) has an elevation of 315 meters. An ice sheet covers the southeast part of the island. The "shield" representing a fairly regular "cupola" terminates in precipitous walls on the east and south shores and in other places it descends gradually, without reaching the sea. On the east the shield sends out a single hanging ice-tongue which does not reach the sea.

A characteristic feature is the location of all this ice shield below the present-day snow line. Hence, the snow feeds the ice "shield" very little. In the summer (1 - 1.5 months) the surface part of the glacier melts vigorously, as a result of which it is subsiding rapidly.

Picture, Page 133

Henrietta Island

The movement of the ice is very slow and takes place chiefly only in the

middle part of the slopes, where we observe radial cracks; on the north and on the west there is a zone of perennial ice.

We also observe glacial formations on the slopes and in the valleys of the islands; they are partly of residual origin, and are for ed in part by the drifting of snow.

The part of Henrietta Island free from ise at the present time is a plateau, terminating steeply at the edge of the sea, formerly subjected to the leveling action of the glacier; this is attested by the presence of roches moutonnees, "curled" rocks, and also a wavy island plain. The island has two considerable elevations: Bennett Mountain on the northwest and Chippa Mountain on the northeast; the altitude of these mountains is about 150 meters; on the side next to the sea these mountains descend almost vertically and on the inland side they descend gradually; the upper part of the mountain is a level space.

The running water, in particular the glacial-river water, has produced terraces, in particular those on the slopes of Bennett Mountain at an altitude of about 105 and 90-95 meters above sea level, and also shallow valleys on the slopes of the plateau. On these slopes we observe the characteristic stone rings, and also the mountain benches. The surface of Bennett Island is of the plateau type; the island terminates abruptly in basalt rocks, reaching elevations of 300 meters. Vilkitsky Island, on which we find only in places a narrow sandy-pebble shore strip, has a shore line consisting of the same kind of basalt rocks but lower ones (up to 100 meters); the eastern shore of this island is sloping; its surface is tundra.

2) The Medvezhi Islands. To the north of the mouth of the Kolyma there is a small archipelago consisting of 6 islands (Krestovski, Pushkarev, Andreev, Leonteva, Lysov, and Chetyrekhstolbovoi), which are known under the general name of Medvezhi Islands. The largest of them is Krestovski Island and the smallest if Andreev Island.

The Medvezhi Islands are made up of granites; it is only on Chetyrekhstolbovoi

island that the shales and hornstones, in contact with the granites, have been conserved.

The island of the Medvezhi group that has been studied most is the one farthest to the east and closest to the continent, namely, Chetyrekhstolbovoi Island, on which there is a polar station. It stretches from the west to the east; it has a length of 10 km and an average width of 2 -- 2.5 km.

Nearly all the island is covered with stone alluvial deposits in the midst of which there rise up, in the east part, four granite columns (hence, the name of the island). The northeast part of the island is an elevated area, the highest point of which is about 100 meters above sea level. In the middle part of the island there are many ravines extending towards the sea; the streams flow through them during the summer.

The shores are indented, in some places they are precipitous and in others they are sloping; in the latter case, on the sloping shore, among the alluvial deposits, we find marshy sectors of tundra, and along the sea shore there are sometimes stretches of shore walls (embankments), behind which we observe here and there small fresh-water lagoons. The most westerly part of the island is an elevated area of a more or less rounded form having an elevation of about 40 meters above sea level, with a steep shore; with the rest and larger part of the island it is connected by a low and narrow isthmus made up of coarse-grained sand.

Steep shores are also a characteristic feature of the other islands of this group.

WRANGEL ISLAND

Wrangel Island has an area of about 8,000 square km and is separated from the continent, with which it has much in common from a geological-geomorphological standpoint, by Long Strait, which has a depth of 40-50m.

The geological structure of Wrangel Island has not been studied sufficiently

by any means. In the northern and central parts of the island there are supposedly outcrops of Lower Paleozoic quartzites, crystalline shales and sandstone, covered by sandstones, limestones clays-carbonaceous shales and more rarely sandstones from the Upper Carboniferous fauna fossils. South of the area of development of the Paleozoic, rocks beloning to the Triassic have a continuous distribution. These are black clay and phyllitic shales with fauna of the Upper Triassic, gray sandstone and variegated lagoon-continental formations (the age of the latter is not entirely clear). In the central part of the island there are "mute" coarse-grained sandstones, quartzites, and conglomerates which break through along with small intrusions of granites. There is also one outcrop of amphibolite. The Triassic and Carboniferous rocks are crumpled into folds of a latitudinal direction, and between them there is angular incongruity. The strike of the Lower Paleozoic is almost meridional.

The useful deposits of Wrengel Island have been studied very little. Associated with the granites of Wrangel Island there are a number of ore formations and also veins of rock crystal. There are reports of the finding of coal on Wrangel Island but as yet they have not been confirmed.

The quaternary deposits of Wrangel Island are exclusively of continental origin. They have their maximum development in the north part of the island where the Akademiya Nauk tundra, for example, is entirely covered by quaternary conglomerates, which have inclusions of plant remains, bones of mammoths, bones of the northern reindeer and residual peat deposits. Such finds indicate the existence of more favorable climatic conditions in the fairly recent past and also of the connection, in quaternary times, of Wrangel Island with the continent. Marine quaternary deposits and other traces of the action of the sea on the island above its present level have not yet been discovered, if we except the finding of rolled pebbles and floating wood at altitudes above 10m.

It is possible that both Wrangel Island and Herald Island are eroded horsts

with a latitudinal direction, formed long before the separation of these islands from the continent. The latter, judging from the character of the quaternary fauna on the islands, did not take place until the second half of the Quaternary period and was probably due to the general subsidence of the north shore of Asia.

The highest point on Wrangel Island is Sovetskaya Mountain located in its central part. The altitude of this mountain, as determined by the expedition of the Academy of Science of the USSR which discovered it in 1938, is 11,007m above sea level. Before this time the highest point on the island was supposed to be Berri Peak with an elevation of 760m.

Wrangel Island may be divided into the following geomorphological areas:

1) a low plain occupying the northern part of the island--the Academy of Science tundra;

2) the low mountains of the northern half of the island;

3) the mountains of medium height of the central part of the island (the central mountain group);

4) the plateau of the eastern part of the island;

5) the low mountains of the southwest part of the island;

6) the sculptured-accumulative coastal plain of the south part of the island.

The tundra of the Academy of Sciences (Akademiya Nauk) is characterized by its greatly worn down relief; in its southern and highest part it reaches an elevation of about 50m above sea level. This area is cut by many small streams flowing towards the sea. There are many subsidence lakes. The locality is covered by spot tundra.

The low mountains located to the south reach an elevation of 350-400m; their peaks are flat or rounded. A wide longitudinal valley separates the low mountains from the area of the mountains of medium altitude, among which are located the highest peak of the island, peaks which are conical or cupola shaped. The mountains in the southwest drop down to 500m or less. South of the mountains

of medium altitude, in the eastern part of the island, there is a slightly dissected plateau with absolute altitudes of 200-400m, and ending abruptly on the east shore. On the elevated sectors there are extensive solifluction mountain terraces (benches). On the extreme south there is a plain.

On the island we often find longitudinal valleys running in the direction of the strike of the rocks making up the island; they are wide and stretch sometimes over the whole length of the island. We also find transversal valleys, though more rarely than the longitudinal ones, and they are narrow and generally continuous. These two systems of valleys create here a grid type of mountain-valley physiographic province, characteristic of the mature stages of the erosion cycle.

Picture, Page 137

Wrangel Island. Mountains in the central part of the island.

A large part of the southern and northern shore lines consists of sandbars and lagoons; in other places the shore has steep cliffs, reaching, on the southeast of the island (area of Gavan Cape) an altitude of 200m.

No precisely identified ancient marine levels have been found on Wrangel Island. There is nothing definite concerning the question of quaternary glaciation, traces of which have been reported by some investigators and disputed by others.

Some investigators have observed small glaciers formed apparently from

drifted snow, lying throughout the year in the shaded and deepest parts of certain valleys.

Wrangel Island is almost always surrounded by ice floes, among which an important role is played by the polar packs. Such ice conditions in the area of the island (in spite of the nearness to the Pacific Ocean) exercise a great influence upon the climate; this influence is noticeable particularly in the summer when the temperature of the air here is much lower than what we might expect in view of the geographical position of the island. Mean monthly temperatures of above zero are characteristic only for June, July, and August; the warmest month is July, and its mean temperature is 2.4°. The coldest month is February with a mean temperature of -25.5°. In summer the prevailing winds are from the southeast (from the Pacific Ocean); in wintertime they are accompanied now and then by thaws. In wintertime (and in general in the course of the greatest part of the year) the prevailing winds are from the northeast and are characterized by a maximum force, sometimes reaching that of a hurricane.

Picture, Page 138

Dogs on the Ice.

Picture, Page 139

Herald Island

A great deal of cloudiness and fogs are very characteristic features of Wrangel Island, particularly in the summer; during this time atmospheric precipitation falls very frequently, chiefly in the form of rain. The small amount of solid precipitation on the one hand, and the strong winter winds on the other condition here the thin snow cover, and in places even the complete absence of the snow cover. This creates the necessary conditions for the extensive distribution of sectors free of vegetation and for the formation of polygonal tundra.

B.N. Gorodkov claims that on the clay plain of the Academy of Science tundra one may observe bare sectors of two types: 1) friable sectors, with separate grassy-mossy sod areas and 2) sectors with a network of troughs, covered with a growth of lichens and mosses. B. N. Gorodkov considers the first of these formations to be the bottom of lakes recently freed of their water (very many of which are present here) and subjected to the action of frost; and the second (polygonal sectors), as the more mature formations associated with dry valley conditions.

The extent the distribution here of such micro-relief may be judged by the fact that 70% of the typical mossy polygonal tundra on the eastern shore of Wrangel Island is bare. On such sectors the frozen ground melts by the end of summer to a depth of 40--45cm; under the grass-moss cover the melting takes place to a smaller depth (20--25cm).

Together with the bare sectors, that is, areas with almost no vegetation

and having no clearly expressed soil cover, there are also areas with a weakly developed thin peat-gley soils, covered with mosses and grasses.

On the moderately steep shale slopes in the central part of the island and on its southern littoral, we find lichen tundra with almost continuous vegetation while the latter is absent on the Academy of Science tundra. On the level drier sectors covered with detritus many times without snow in the wintertime we observe lichen polygonal tundra characterized by only partial plant cover.

In the valleys of the central part of the island, particularly on the south slopes, and on the south littoral, the vegetation is characterized by a considerable variety and a maximum degree (though incomplete) of continuity; here we find various kinds of willow.

Among the land mammals on Wrangel Island are the lemming and many polar foxes. Here there are more white bears than in other areas of our Arctic, but there are no northern reindeer at all. Reindeer do not come here even in their migrations, though as we pointed out above they penetrate, for example, as far as the archipelago of Franz Josef Land. In the summer, on the littoral, there are many rookeries of walruses, which migrate towards the south in the fall. There are many "ringed" seals; in the waters of the Chuckchee Sea we find the Greenland whale, the narwhale and the beluga. There are large numbers of geese, especially white geese (Chen hyperboreus Pall) (This species is extensively distributed over the America arctic); in other places in our country they are very rare and on the continent of East Siberia they have been almost exterminated. White geese still nest on Wrangel Island in large numbers, gathering in large colonies ranging from 10 to 20 pairs up to several thousands. The distance between the colonies is 1 to 2 km. For the inhabitants of Wrangel Island the gathering of eggs of these geese is an important occupation. Other important activities are the hunting of game in the summer, the walrus industry and winter hunting of polar fox and white bear. Among other birds we shall mention the large numbers of black brant, eider ducks, "forked-tailed" gulls, snow buntings, and polar owls. On Wrangel Island we find a total of 42 species

of birds, but only one half of this number normally make their nests here; the rest happen to fly in or they may be driven here by storms, from the continent. There is a large "bazaar" of thick-billed gulls on the eastern shore of the island.

HERALD ISLAND

Herald Island, located 70 km from Wrangel Island, stretches from the northwest to the east-southeast; it is only 8 km long; its maximum width (in the southeast part) is about 2 km. On Herald Island the only outcrops are granites and hornstone and quarzites, metamorphosed in contact with them. On the northwest the island is a rocky ridge projecting from the sea. The surface of the interior part of the island is a flat area above which rises separate peaks (100--150m), greatly worn down by the processes of weathering absolute altitudes of 250--350m); the surface of the island is covered with alluvial deposits; in places there is a tundra cover of mosses and lichens. The shore of the island is high and steep almost everywhere and, hence, access to it is very difficult.

LIST OF PLANTS MENTIONED IN THE TEXT

Knotweeds - Polygonum viviparum

Alsine - Stellaria Edwardsii

Saxifrage - Saxifraga oppositifolia

Drooping saxifrage - Saxifraga cernua

Saxifrage - Saxifraga comosa

"Koenigia" - Koenigia islandica

Ragwort - Senecio congestus

Whitlow grass - Draba alpina

Dryas - Dryas octopetala

Spoonwort - Cochlearia arctica

Crowfoot - Ranunculus nivalis

Polar poppy - Papaver radicatum

Luzula nivalis - Luzula nivalis

Siphons (red algae) Polysiphonia arctica

Phillozia - Phyllaria lorea

Phillophora - Phyllophora interrupta

Aira - Deschampsia arctica

LIST OF VERTEBRATE ANIMALS MENTIONED IN THE TEXT

Cormorant - Phalacrocorax carbo

Beluga (white whale) - Delphinapterus leucas

White goose - Chen hyperborea

White bear - Thalassarctos maritimus

Gull ("Burgomistr") Larus hyperboreus

Wolf - Canis lupus

Raven - Corvus corax

East Siberian eider duck - Somateria mollissima

"Comb" eider duck Somateria spectabilis

Loon - Colymbus stellatus

Ordinary eider duck - Somateria mollissima

Razor-billed auk - Alca torda

Char - Salvelinus alpinus

Hump back whale - Megaptera nodosa

Plover - Aegialitis hiaticula

Brant - Branta bernicla

Guillemot - Uria aalgae

Thick billed guillemot - Uria lomvia

"Kamenshka" - Arenaria interpres

Killer whale - Orca gladiator

Greenland whale - Balaena mysteceteus

Grey whale - Rhachianectes glaucus

Blue whale - Balaenoptera musculus

Gasterosteid fish - Gasterosteus aculeatus

Lemming - Dicrostonyx torquatus

Tern - Sterna paradisea

Histriophoca fasciata - Histriophoca fasciata

Vituline seal - Phoca vitulina

Bewicks' swan - Cygnus bewicki

Swooping swan - Cygnus cygnus

Ordinary fox - Vulpes vulpes

Auk - Alle alle

Walrus - Odobaenus rosmarus

Coxing Walrus - Odobaenus rosmarus divergens

Bearded seal - Erignathus barbatus

Narwhale - Monodon monoceros

"ringed" seal (or floe rat) - Phoca hispida

Ob lemming - Lemmus obensis

Perch - Sebastiens marinus

"Cisco" (kind of salmon) - Coregonus autumnalis

Arctic fox - Vulpes lagopus

Sandpiper - Calidris maritima

Haddock - Melanogrammus aeglifinus

Northern phalarope - Lobipes lobatus

Rorqual (red whale) - Balaenoptera acutorostrata

Pomarine jaeger - Stercorarius pomarinus

Snow bunting - Plectrophenax nivalis

"Nyagushka" (a kind of salmon -) - Coregonus sardinellus Nasis-albi

Pollack - Pollachius virens

Polar cod - Boreogadus saiga

Harbor porpoise - Phocaena phocaena

Reindeer - Rangifer tarandus

Roller - Coracias garrula

White owl - Nyctea nyctea

Magpie - Pica pica

Grey seal - Halichoerus grypus

Puffin - Fratercula arctica

Codfish - Gadus morhua

White sea whale - Histriophoca groenlandica oceanica

Greenland whale - Histriophoca groenlandica

Finback whale - Balaenoptera physalus

Hooded seal - Cystophora cristata

Ivory gull - Pagophila eburnea

Seagull - Larus marinus

Herring gull - Larus argentatus

Mew - Larus canus

"Tridactyl" mew - Rissa tridactyla

Razor-billed auk - Cepphus mandtii

Pintail duck - Anas acuta

Shoveler - Anas clypeata

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